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The achievement of content and understandings of the scientific enterprise of students in the Interaction of Matter and Energy Program (IME) and conventional physical science classes was compared. The experimental group consisted of 372 pupils from 13 classes while the control group had 275 students from 12 classes. Students were pre- and post-tested with the Sequential Test of Educational Progress (STEP) Science Achievement Test and the Test on Understanding Science (TOUS). "The results indicate that the IME is successful in providing an understanding of science particularly in the area of methods and aims of science with pupils of normal or above normal mental ability when taught by teachers who are adequately trained in physical science." [Not available in hard copy due to marginal legibility of original document.] (BC)

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THE EFFECTIVENESS OF IME

BY

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OFFICE OF EDUCATION

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Abstract

The purpose of the study was to answer the following questions: Do pupils using the Interaction of Matter and Energy Program score significantly higher in general science achievement than those taught in conventional physical science classes? Do pupils using the Interaction of Matter and Energy score significantly higher in their understanding of science - scientific enterprise, scientists and methods and aims of science than students taught in conventional physical science classes? The study involved 647 students from seven schools. The experimental group consisted of 372 pupils from 13 classes. The control group consisted of 275 students from 12 classes. The students were given pre and post Step Achievement Tests, Science and TOUS, understanding about science tests. Data were collected and analyzed by non-parametric statistics to reveal any significant difference to variables of teacher preparation, the briefing session and intelligence. The data revealed that only one school had any significant differences between the experimental and the control groups in general science achievement gain scores. The gain in achievement was at the 90-109 I.Q. level and the 110-119 I.Q. level.

Statistical differences in the understandings of science were in four of the seven schools that participated. One school showed significant difference in understanding about the scientific enterprise at the 90-109 I.Q. level. Another school had significant differences in the understanding about scientists at the 110-119 I.Q. level. The four schools had significant gains at 90-109 I.Q. levels and all other levels above the 90-109 I.Q. levels in the understandings about the methods and aims of science. The results indicate that this program is successful in providing an understanding of science particularly in the area of methods and aims of science with pupils of normal or above normal mental ability when taught by teachers that are adequately trained in physical science. In the

realm of achievement, the above criteria are necessary along with adequate background of general science prior to taking the course. Attendance to the briefing session had little or no influence.

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APPENDICES

A - Number and Per Cent of Students Enrolled in Physical Science and Participating in the Study

B - Interquartile Norm Ranges

C - Interquartile I. Q. Ranges

D - Tentative Norms - Test on Understanding Science (TOUS) Percentile Ranks for High School Students

THE NATURE AND SIGNIFICANCE OF THE STUDY

It is a well-known fact that since the launching of Sputnik I by the Soviet Union in October, 1957, scientists and educators in the United States have been engaged in the development of new approaches, curricula, and programs for the teaching of science in elementary and secondary schools. However, the elementary science endeavor is the more recent undertaking.

It is commendable that these knowledgeable persons are so concerned that they are willing to devote their full attention to the development and implementation of new programs and materials in science. However, there is a paucity of research available to indicate that students possess greater knowledge about the nature of science or understand scientific concepts better as a result of having participated in such programs. In fact, instead of an increasing number of experimental research studies in science education, the opposite has occurred. The number of such studies is on a decline. Taylor and his associates report that the number of experimental studies in science education has decreased from 22.4 percent for the 1961-63 biennium to 14.4 percent for the biennium of 1963-65.[1]

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[1]Taylor, Wayne., et al., Review of Research Studies in Science Education, ERIC (Educational Resource Information Center of U.S. Office of Education), Table 3 - ED 012 235.

DESIGN OF THE STUDY

The Study Group: The study group consisted of 647 students from twenty-five science classes. There were 372 representing thirteen classes in the experimental group and 275 students from twelve classes in the control group. The students composing the study groups were from seven schools.

Procedure for Collecting Data: The following steps were taken in acquiring data in the study.

1. Test booklets and answer sheets were collected from each participating school at the conclusion of each testing period.
2. The STEP tests and the Otis Quick Scoring Mental Tests were scored on the 1230 IBM machine in the North Carolina Department of Public Instruction.
3. The TOUS tests were scored at the Educational Testing Service Center at the University of North Carolina, Chapel Hill, North Carolina 27514.

Treatment of Data: The collected data was tabulated and analyzed, and necessary calculations were made. Data regarding STEP and TOUS scores were subjected to non-parametric statistical tests, the Mann Whitney U Test and the Kruschal Wallis One Way Analysis of Variance. For statistical control, pupils were grouped according to the conventional I. Q. classifications.

ORGANIZATION OF THE STUDY

Chapter II contains background information pertinent to this investigation. Chapter III presents the distribution of I.Q. scores for the study group. Chapter IV presents findings regarding the general science achievement of the study group. Results of the Test on Understanding Science taken by the stydy group may be found in Chapter V. The summary, conclusions and recommendations are in Chapter VI.

Test on Understanding Science, Form W, (TOUS). A standardized test designed to assess the extent of understanding science and scientists.[5]

I.Q. - A score derived from Otis Quick Scoring Mental Ability Test, Gamma. The test is designed to measure mental Ability[6] - thinking power or the degree of maturity of the mind.[7]

LIMITATIONS AND BASIC ASSUMPTIONS

This study was limited to an evaluation of the data received from tests taken by the study group, information about school size, and teacher preparation.

It was necessary that the following basic assumptions be made regarding this investigation.

1. The Sequential Tests of Educational Progress is a valid and reliable instrument for measuring what it purports to measure.
2. The test on Understanding Science is a valid and reliable instrument for measuring what it purports to measure.
3. The Otis Quick Scoring Mental Test is a valid and reliable instrument for measuring what it purports to measure.

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[5]"Manual for Administering, Scoring and Interpreting Scores TOUS (Test on Understanding Science). Form W" (1961) Educational Testing Service, Princeton, N. J.

[6]Otis, Arthur S., "Manual of Directions for Gamma Test, Forms AM and BM and New Edition: Form Em and FM." (1939-1954) Harcourt, Brace and World, Inc., New York.

[7]"Tables for Deriving I.Q. 's on Otis Quick Scoring Mental Ability Test, Gamma," Test Department, Harcourt, Brace and World.

DEFINITION OF TERMS

Terms which have special meaning with respect to this study are:

Interaction of Matter and Energy Program - (IME) "A science curriculum based upon the inquiry system of teaching and learning. This system includes observation, investigation, interpretation, research of appropriate literature and critical study of conclusions leading to (1) an understanding of the processes of science and (2) an acquisition of fundamental science knowledge. Most investigations are structured so that teachers may guide students toward achieving maximum understanding through independent discovery."[3]

Conventional Physical Science

A science program based primarily upon a lecture/demonstration approach to teaching whose basic intent is to encourage the learner to "master" certain significant science concepts.

Students involved in this approach used the State-adopted text, "The Physical World", 2nd Edition, Brinckerhoff, Cross, Watson, Brandwein, 1963, Harcourt, Brace and World.

SequentialTest of Educational Progress, Science (STEP) A standardized test designed to measure ability to use scientific knowledge to solve problems.[4]

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[3]"Interaction of Matter and Energy, An Introduction to Physical Science" - A Rand McNally Science Curriculum Project - Rand McNally and Company, Preface to the Teacher.

[4]"Manual for Interpreting Scores, Science". Cooperative Sequential Tests of Educational Progress. (1957) Cooperative Testing Division, Educational Testing Service, Princeton, N.J.

introduced and utilized by some of the schools during the 1967-68 school year, it was decided that a study of this program would provide some insight into its effectiveness in the areas of pupil achievement and understanding in science.

Therefore, it was the purpose of this study to answer the following questions regarding the Rand McNally Science Curriculum Project.

1. Do pupils enrolled in classes utilizing the "Interaction of Matter and Energy" program score significantly higher in general science achievement, as measured by the STEP test, than students taught in the conventional physical science class?
2. Do pupils enrolled in classes utilizing the "Interaction of Matter and Energy" program score significantly higher on understandings about the scientific enterprise as measured by the Test on Understanding Science, than students taught in conventional physical science classes?
3. Do pupils enrolled in classes utilizing the "Interaction of Matter and Energy" program score significantly higher on understanding about scientists, as measured by the Test on Understanding Science than students taught in conventional physical science classes?
4. Do pupils enrolled in classes utilizing the "Interaction of Matter and Energy" program score significantly higher on understandings about the scientific method and investigation, as measured by the Test on Understanding Science, than students taught in conventional physical science classes?

CHAPTER II

THE BACKGROUND OF THE STUDY

In an effort to gain some insight into the effectiveness of the new science curricula in the areas of pupil achievement and understanding in science, the science section of the North Carolina Department of Public Instruction in the spring of 1967 initiated a program to evaluate new science curricula.

Since the Rand McNally Science Curriculum Project, "Interaction of Matter and Energy, An Introduction to Physical Science," was to be introduced in some of the public schools across the State during the 1967-68 school year, it was decided that a study of this program would be an initial step toward evaluation of such programs.

Selection of Participating School Units

Seven school superintendents representing the eastern, piedmont, and western geographical regions of the State were contacted by the Science Staff of the North Carolina Department of Public Instruction to seek permission for schools in their units to participate in the study.

The Initial Sample

The initial sample included nine schools, sixteen teachers, twenty-nine classes and 882 students. There were 486 students in the experimental group and 396 in the control. One school dropped out and one school was deleted from the statistical analysis because of incorrect procedure. There was also attrition for the usual causes: dropouts, transfers and absenteeism during the testing days.

The Final Sample

The final sample consisted of 647 students, with 275 in the control and 372 in the experimental group. These students were taught by fourteen teachers in twenty-five classes. Twelve classes were in the control and thirteen classes in the experimental group. Seven schools were involved. This is shown in Table V.

Number and Types of Schools Participating

Nine schools representing seven school units were initially selected to participate in the study. As can be seen in Table I, the school types represented were union, junior and senior high schools. Union schools encompass grades 1-12. Junior high schools contain 7, 8 and 9; and senior high schools, grades 9-12. The size of the school units ranged from slightly over 5,000 pupils to greater than 20,000. The student body size varied from 450 to over 1300. The number of physical science teachers per school ranged from one teacher to five teachers with most of the schools having two physical science teachers each.

Types of Communities of Representative Schools

As revealed in Table I, the community types of these schools were rural, semi-rural and urban. The population in these communities ranged from a few hundred in the rural to over 250,000 in the urban areas.

Table I

Description of Community and School Composition

School	Unit Size	Community Type	School Type	Student Body	Total No. of Teachers	Phy. Sci. Teachers
A	> 5000	Rural	Grades 1-12 Union	1354	47	2
B	>9000	Rural	Grades 1-12 Union	955	39	2
C	>9000	Semi-Rural	Grades 1-12 Union	952	44	5
D	>20000	Urban	Grades 7-9 Jr. High School	1370	42	2
E	>20000	Urban	Grades 7-9 Jr. High School	1394	50	2
*F	> 9000	Semi-Rural	Grades 1-12 Union	657	26	1
G	> 9000	Rural	Grades 9-12 High School	631	32	2
/H	< 5000	Semi-Rural	Grade 9-12 High School	450	20	1
I	>20000	Urban	Grades 7-9 Jr. High School	1022	47	2
Total				8785	347	19

* Voluntarily dropped out

/ Not in statistical analysis

Number of Teachers and Type of Science Preparation of Teachers in Study

There were a total of sixteen physical science teachers initially participating in the study. All teachers involved in the program were invited to Atlanta, Georgia, for a three day briefing program in August, 1967. However, as table II indicates only nine of the sixteen participating teachers attended the briefing. Two of the attending teachers dropped out leaving a total of seven teachers attending and seven not attending the briefing.

The Atlanta Briefing Session acquainted the teachers with the program. It also gave them an opportunity to play the role of a student by working through laboratory investigations.

All of the teachers teaching the IME Program were properly certified to teach science although one teacher in the control group was not certified to teach science.

As can be seen in table III, the undergraduate physical science preparation of these teachers ranged from zero to six courses in chemistry. The average number of undergraduate chemistry courses was 2.7. The average number of undergraduate physics courses taken by the teachers in this study was 1.4.

Four of the fourteen teachers had taken graduate courses in chemistry The number of courses taken by these teachers ranged from one to three. Only two teachers had taken any graduate courses in physics. Each of these two teachers had taken two courses. Table III shows these data.

Table II

Teachers Attending The Atlanta Briefing

Unit	Teacher	School	Attended	Did Not Attend	Total
I	J. L.	A	X		
	B. L.	A		X	2
II	W. A.	B	X		
	H. B.	B		X	2
II	E. W.	C		X	
	E. T.	C		X	
	T. A.	C		X	5
	C. D.	C		X	
	A. S.	C	X		
III	B. F.	D	X		1
	M. M.	E	X		1
IV	L. F.	* F	X		1
V	M. L.	G	X		1
VI	R. S.	≠ H	X		1
VII	W. B.	I	X		
	W. M.	I		X	2
Total			9	7	16

* Voluntarily dropped out

≠ Not in statistical analysis

Table III

Number of Physical Science Courses
Taken by Teachers

	Undergraduate		Graduate		Total
Teacher	Chemistry	Physics	Chemistry	Physics	
1. A.S.	4	2	-	-	6
2. J.L.	4	1	-	-	5
3. W.B.	3	1	3	2	9
4. M.L.	2	2	-	2	6
5. W.A.	1	2	1	-	5
6. B.F.	2	2	-	-	4
7. M.M.	3	1	1	-	5
8. W.Mc.	6	2	2	-	10
9. C.O.	2	-	-	-	2
10. D.L.	2	3	-	-	5
11. H.B.	4	2	-	-	6
12. T.A.	2	-	-	-	2
13. E.T.	-	-	-	-	0
14. E.W.	2	2	-	-	4
Total	37	20	7	4	69
Average	27	1.4	0.5	.28	4.9

The average number of total physical science courses taken by these teachers was 4.9. The total number of courses taken by the teachers ranged from two to ten exclusive of the one teacher who had not taken any courses in physical science.

Teacher Assignment

As can be seen in Table IV, in five of the participating schools the experimental and control groups were taught by the same teacher. In one of these five schools where there were two teachers, each teacher had control and experimental classes. Table V discloses the class sizes of the experimental and control groups.

Testing of Students

Students were given pre and post tests of the STEP Science Test. Forms 3A and 3B were alternated for the fall and and spring testing. They were given pre and post test of TOUS Form W. Otis Quick Scoring Mental Ability - Gamma Test was given in the spring with the exception of one school that received the test in the fall. The students were given alternate forms of AM and FM of the mental test.

SUMMARY

1. The study group consisted of 647 students from seven schools, representing seven school units.
2. The types of schools represented were union, junior high and senior high schools.
3. The types of communities represented were rural, semi-rural and urban.

Table IV

Teacher Assignment

Unit	School	Teacher	Classes	Control & Expt.	Expt. Only	Control Only
I	A	J. L.	2	X		
	A	B. L.	1			X
II	B	W. A.	1		X	
		H. B.	1			X
	C	E. W.	1			X
		E. T.	1			X
		T. A.	1			X
		C. O.	1		X	
		A. S.	1		X	
III	D	B. F.	2	X		
	E	M. M.	2	X		
* IV	F	L. F.	2		X	
V	G	M. L.	2	X		
⁄ VI	H	R. S.	2	X		
VII	I	W. B.	4	X		
	I	W. M.	5	X		
Total 7	9	16	29	7	4	5

* Deleted from statistical analysis

⁄ Dropped out of the study

TABLE V

Distribution of Experimental and Control Classes by School & Teacher

School	Class	No. of Teachers	Control Classes	Experimental Classes	School Total
A	1	D. L.	19		
	2	J. L.	12		
	3	J. L.		45	76
B	5	H. B.	15		
	6	W. A.		13	28
D	7	B. F.		25	
	8	B. F.	26		51
E	9	M. M.	24		
	10	M. M.		33	57
G	11	M. L.		27	
	12	M. L.	28		55
C	15	E. W.	39		
	16	A. S.		26	
	17	T. A.	13		
	18	C. O.		30	
	19	E. T.	24		132
* Ia	20	W. B.		25	
	21	W. B.		30	
	22	W. B.	29		
	23	W. B.		33	117
* Ib	24	W. Mc.	21		
	25	W. Mc.		31	
	26	W. Mc.		27	
	27	W. Mc.		27	
	28	W. Mc.	25		131
Total	25	14	275	372	647

* Total students Ia and Ib - 248

4. Seven of the fourteen teachers in the study attended the Atlanta Briefing Session.

5. The average number of undergraduate courses in chemistry and physics taken by the fourteen teachers in the study group was 2.7 and 1.4, respectively. Only four teachers had enrolled in graduate chemistry and physics courses.

CHAPTER III

DISTRIBUTION OF I.Q. SCORES

For statistical control, the pupils were grouped according to the conventional I.Q. classification scheme. Figure I provides insight into the number of pupils in each I.Q. range. It indicates that approximately one half were in the normal intelligence range of 90-109. There were over twice as many students above the normal as there were below the normal intelligence range. Only three pupils had I.Q.'s in the 60-69 level.

School A: As revealed in Table VI, student I.Q. scores were in all levels with the exception of the 60-69 level. The experimental class, however, was the only class in this school that had I.Q. scores in the 120-129 range.

School B: All of the I.Q. scores were below normal with the exception of one in the normal range. The score concentration was in the two levels, 80-89 and 70-79. There was one student whose I.Q. was in the 60-69 range. Table VII discloses this information.

School C: School C had a definite imbalance between experimental and control classes in the number of scores found in the various levels of I.Q. classification. As indicated in Table VI, the two experimental classes were the only ones that had students in the I.Q. classification above the normal 90-109 range. Forty-seven students were below the normal range.

School D: As can be seen from Table VI, the experimental and control classes were approximately balanced in the numbers of students in the I.Q. levels. All students had I.Q. scores in normal or above normal ranges exclusive of two in the control class.

School E: The I.Q. scores of experimental and control student's were approximately equal with the exception of the 120-139 level. At that level there were eight from the experimental group in contrast to two from the control group. Table VI reflects this information.

GROUP DISTRIBUTION OF I.Q. SCORES

Figure 1

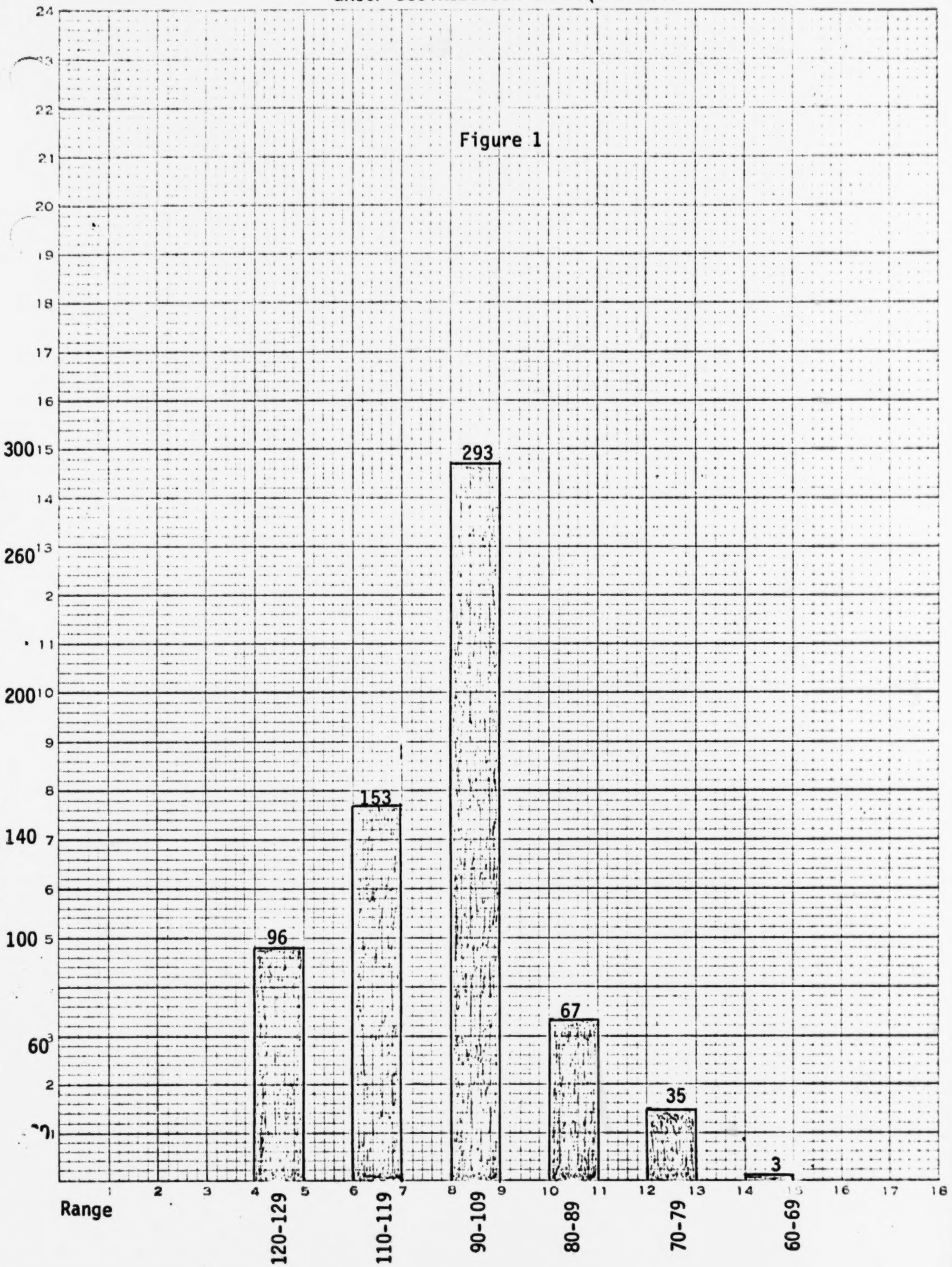


Table VI

Distribution of I.Q. Scores by Classes

	A			B		D		E		G		C					Ia				Ib					
	C	C	E	C	E	E	C	C	E	E	C	G	E	C	E	C	E	E	C	E	C	E	E	C	E	TOTAL
	1	2	3	5	6	7	8	9	10	11	12	15	16	17	18	19	20	21	22	23	24	25	26	27	28	
120 - 139	-	-	4	-	-	2	2	2	8	7	7	-	2	-	2	-	5	9	1	12	2	12	9	10	-	96
110 - 119	-	1	3	-	-	7	7	9	11	11	7	-	8	-	5	-	12	14	3	11	3	15	10	15	1	153
90 - 109	11	9	25	1	-	16	15	13	13	9	14	21	13	2	20	12	7	7	23	9	16	4	8	2	23	293
80 - 89	7	2	6	10	7	-	2	-	1	-	-	11	3	4	1	9	1	-	2	-	-	-	-	-	1	67
70 - 79	1	-	7	3	6	-	-	-	-	-	-	5	-	7	2	3	-	-	-	1	-	-	-	-	-	35
60 - 69	-	-	-	1	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	3
Total	19	12	45	15	13	25	26	24	33	27	28	39	26	13	30	24	25	30	29	33	21	31	27	27	25	647

School G: In school G, the only senior high school participating in the study, I.Q.'s of all participants were in the average and above average ranges.

School I: As shown in Table VI, classes were grouped into two divisions, a and b. Each division was taught by a different teacher. Out of the two hundred forty-seven pupils involved in this investigation, only five had I.Q. scores below normal.

Summary

1. The median I.Q. for the study group was 103-90.
2. There were twice as many students above the normal range as there were below the normal range.

CHAPTER IV

The General Science Achievement of the Study Groups

On the STEP general science achievement test fourteen of the twenty-five classes' median scores were above the national median score of 271 in the fall testing. Six of these fourteen classes were in the control group.

Ten classes' median scores were in the upper quartile range. One of these was a control class.

Results of the spring testing revealed that seventeen of the twenty-five classes' median scores were above the national median. Of that number seven were control classes.

The Mann-Whitney U test was used to determine if there was any significant difference in the gain of the experimental and control classes for schools that had one experimental and one control class. However, for schools that had three or more classes, Kruskal One Way Analysis of Variance was used to determine if there were any significant differences.

School A. As indicated in Figure 2, school A's three classes in the fall were below the national median score. The median scores of classes 1, 2, and 3 were 264.5, 267, and 267 respectively.

The ranges of the STEP scores for these classes were from the first quartile to the third quartile.

The spring test median scores were 263, 272, and 269. One of the control classes had a median score above the national median.

The range of scores in the spring testing in all three classes was from the first quartile to the third quartile.

Kruskal One Way Analysis of Variance revealed no significant differences in gain scores of the experimental and control classes of School A. Table VII disclosed this finding.

Figure 2

Median Achievement Scores and Range of Achi ement Scores of School A Classes

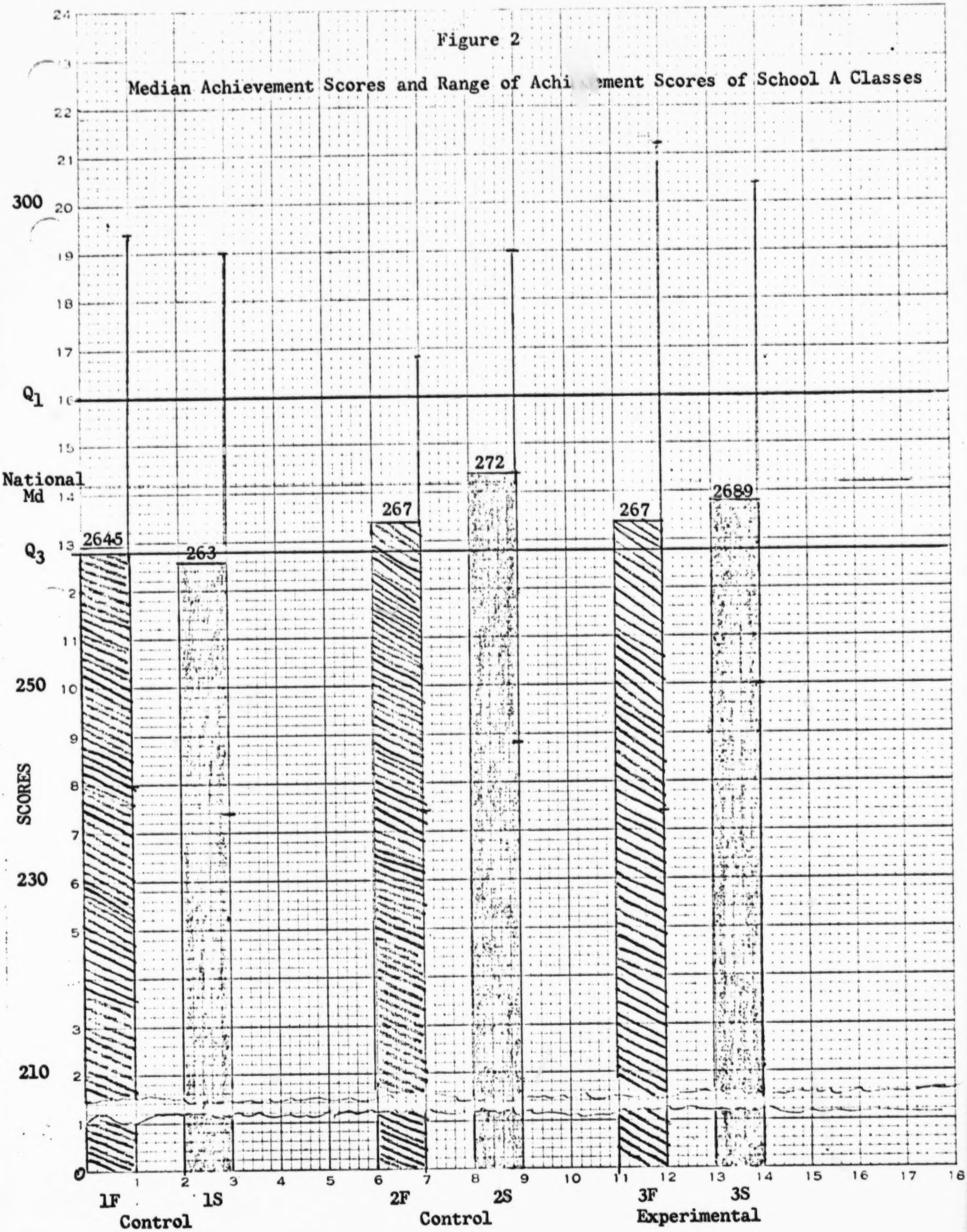


Table VII

Step Science Statistical Results

	A			B		D		E		G		C					Ia				Ib				
IQ	1	2	3	5	6	7	8	9	10	11	12	15	16	17	18	19	20	21	22	23	24	25	26	27	28
120 - 139		-			-		NS		NS		NS			-					-				-		
110 - 119		-			-		NS		NS		NS			-					Significant .05				NS		
90 - 109		NS			-		NS		NS		NS			NS					NS				Significant .01 .05		
80 - 89		NS			NS		-		-		-			-					-				-		
70 - 79		-			NS		-		-		-			-					-				-		
60 - 69		-			-		-		-		-			-					-				-		

School B. The median scores for the experimental and control classes for School B were below the national median score. The fall and spring median scores were in the lower quartile. Figure 3 reflects this finding.

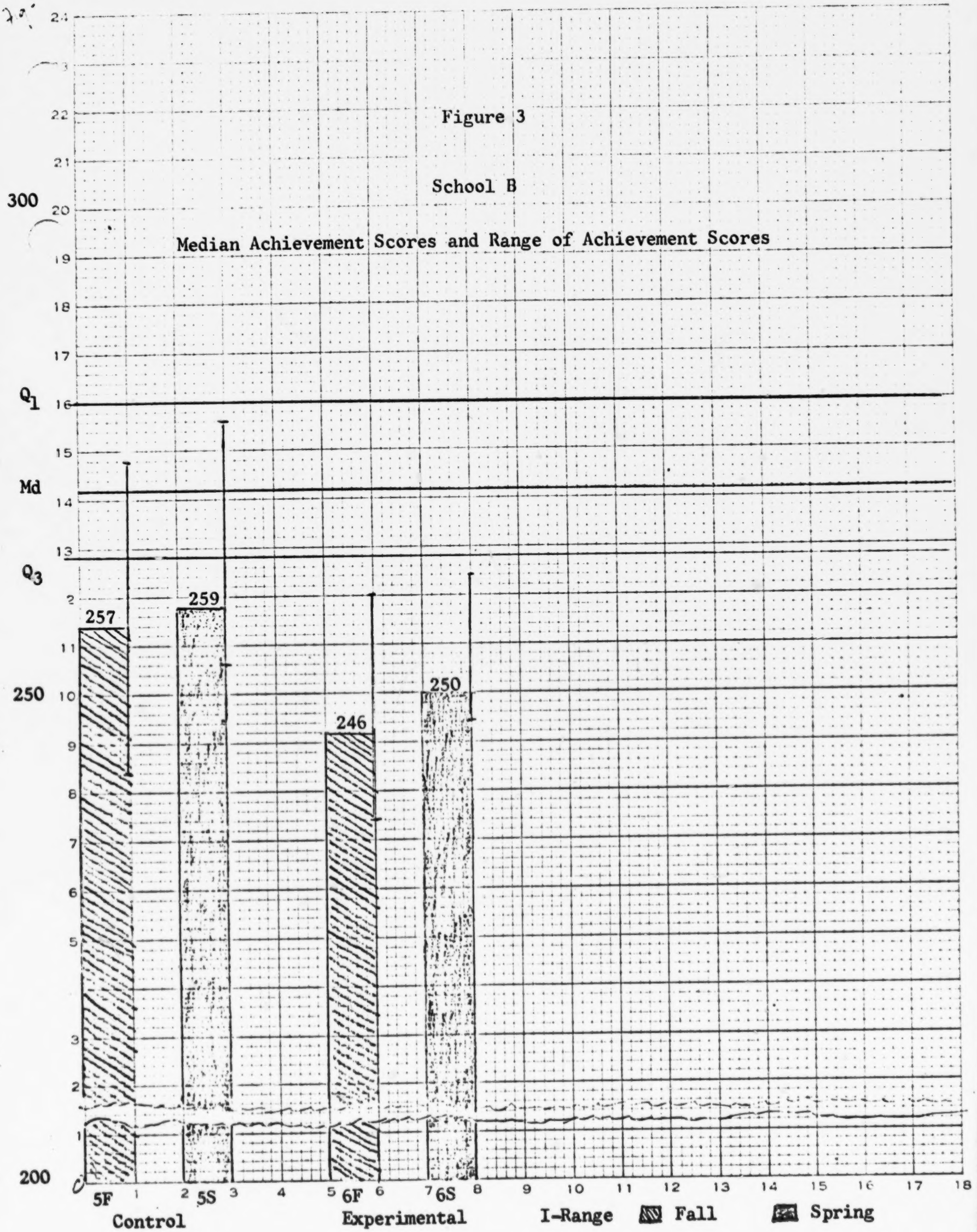
The range of the control class scores extended beyond the national median, but not into the third quartile. The experimental class range did not pass the first quartile.

As can be seen in Table VII, there was no significant difference between the experimental and control classes.

Figure 3

School B

Median Achievement Scores and Range of Achievement Scores



School C. As shown on Figure 4 the median STEP pre-test score for the five classes ranged from 252 in one of the control classes to 281 in one of the experimental classes. The pre test and the post test median scores of the three control classes were below the national median score. The median score of the control classes were in the first quartile with the exception of one class's fall median score.

The range of scores for the control classes was from the first quartile to the third quartile for the pre and post testing with the exception of one class.

The two experimental classes' pre test STEP median scores were above the national median score. One experimental class's median score was in the third quartile. On experimental class had an increase of three points in its median score while the other experimental class had a decrease of three points. The range of the post-test was from the first quartile to the third quartile.

Statistical analysis showed there were no significant differences among the control and experimental classes.

School D. School D classes' median scores were above the national median score. As revealed in Figure 5 fall testing results indicated medians of 274 for the control and 276 for the experimental group. The range of scores for both classes extended from the first quartile to the third quartile. In the spring testing there was a net gain of three points in the control group. The experimental class gained four points to increase their median to the third quartile. The spring test range of scores was similar to those obtained in the fall testing.

Figure 4

School C

Median Achievement Scores and Range of Achievement Scores

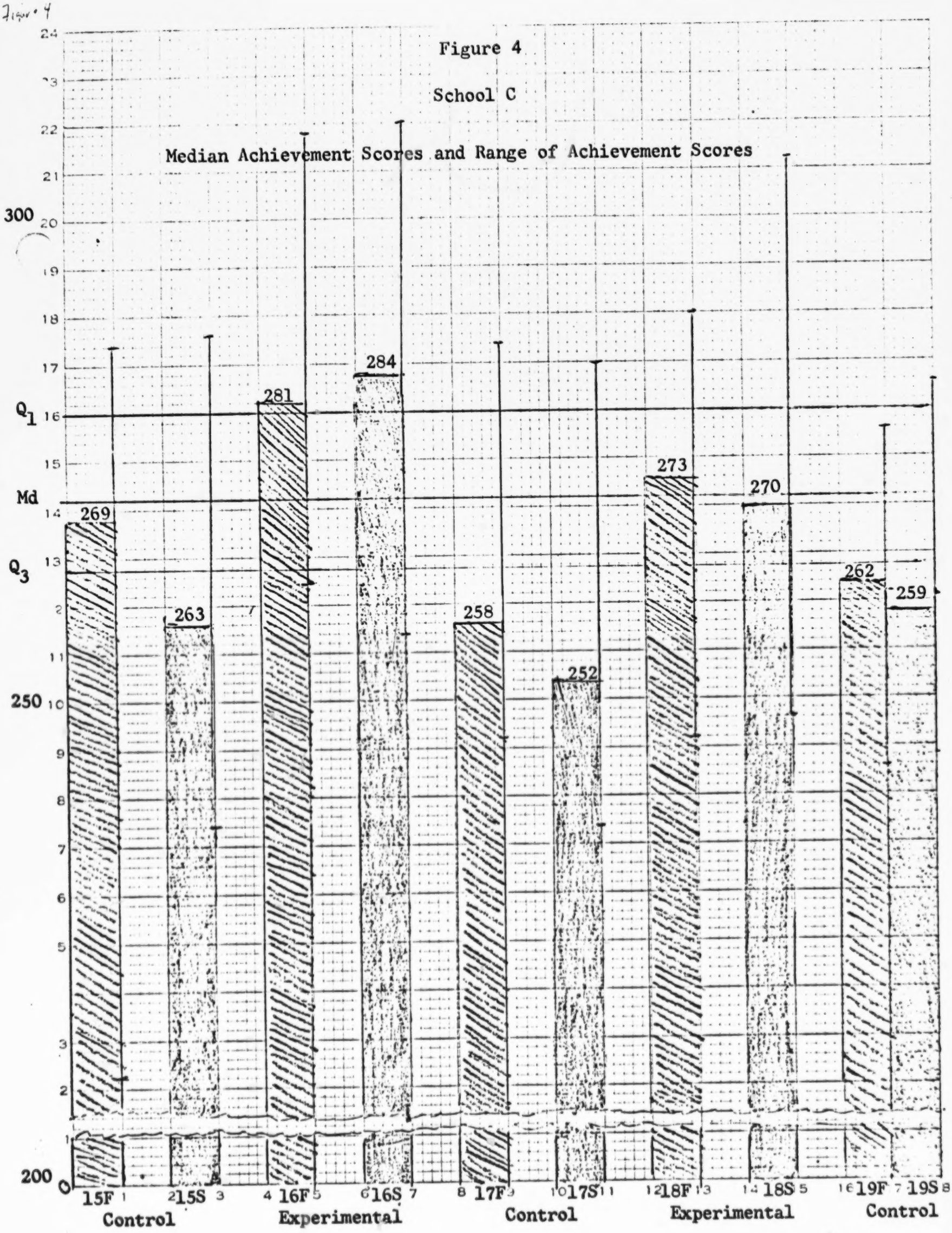
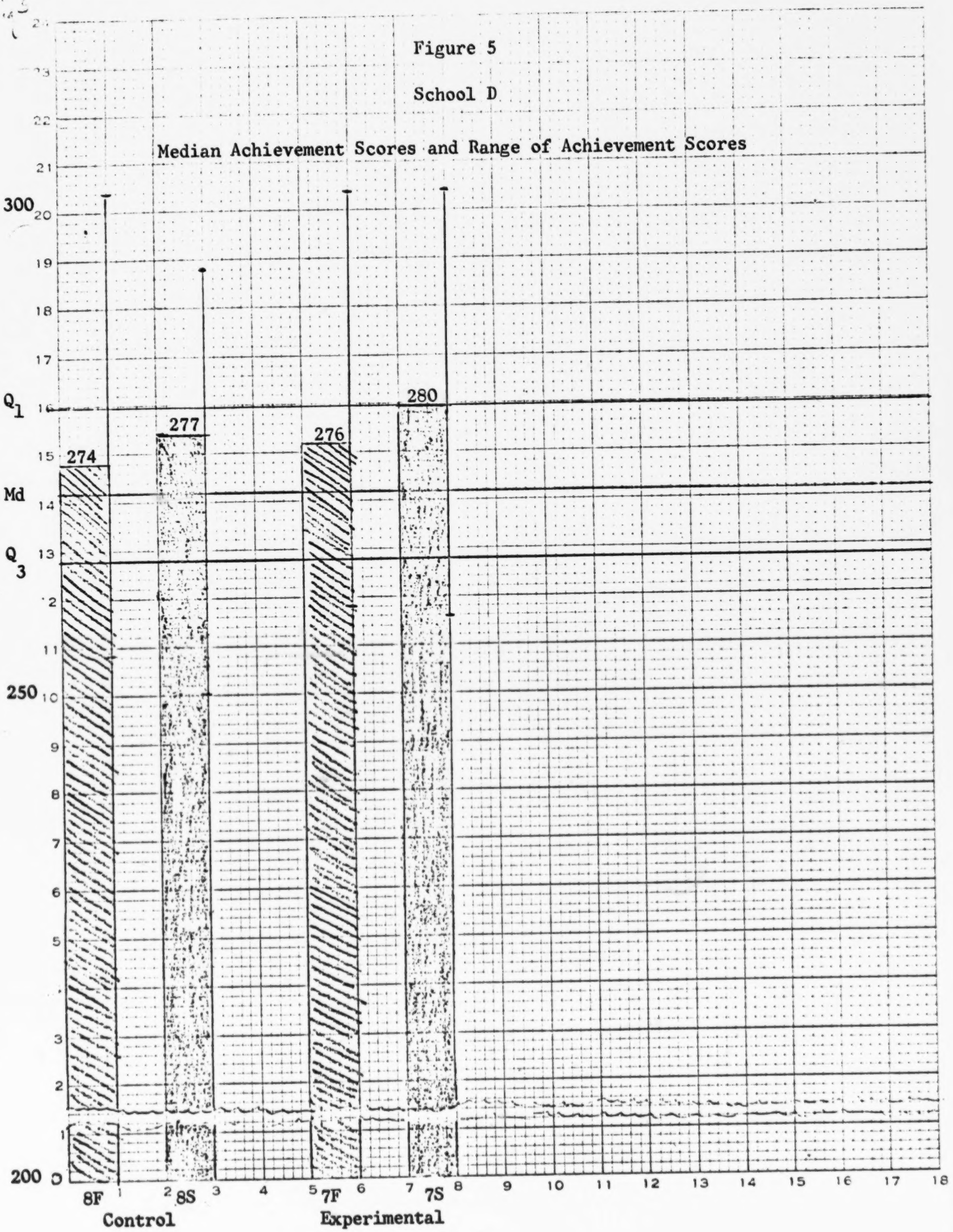


Figure 5

School D

Median Achievement Scores and Range of Achievement Scores



Statistical analysis showed no significant difference between the experimental and the control groups.

School E. The median scores of the experimental and control classes were above the national median on pre test STEP test given in the fall. The range of scores for both groups was from the first to the third quartile. The median score of the control group increased from 281 in the fall to 283 in the spring. The experimental class median score increased from 281 in the pre test to 289 in the first test given in the spring. The experimental class made a net increase of 8 points. Figure 6 presents these findings. There were, however, as table VII indicates, no statistically significant differences for any of the I.Q. levels between the experimental and control classes.

School G. The fall median STEP score for the experimental class was 283. As shown in Figure 7 this was three points above the seventy-fifth percentile rank. The experimental spring median score increased to 287.

The range of scores was from the first quartile to third quartile in the pre and post testing of STEP test for the experimental classes.

The control pre and post test median scores were above the national median score. The post median test score was in the third quartile for the control. The range of STEP scores was from the first quartile to the third quartile.

Statistical analysis indicated no significant difference between control and experimental students of the same I.Q. level.

School I. For statistical analysis participating students were divided into two divisions. Each division or grouping was taught by a separate teacher.

Figure 6

School E

Median Achievement Scores and Range of Achievement Scores

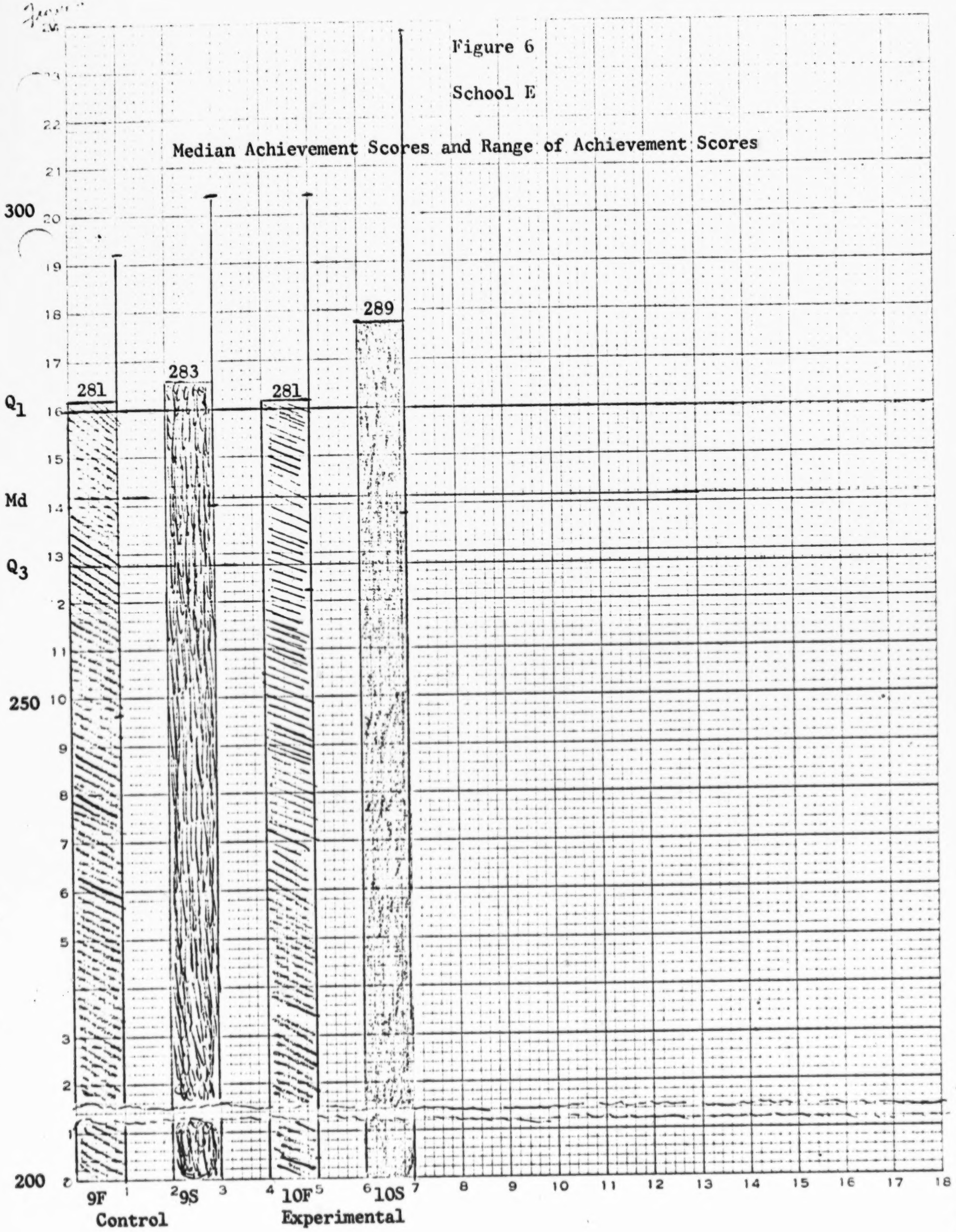
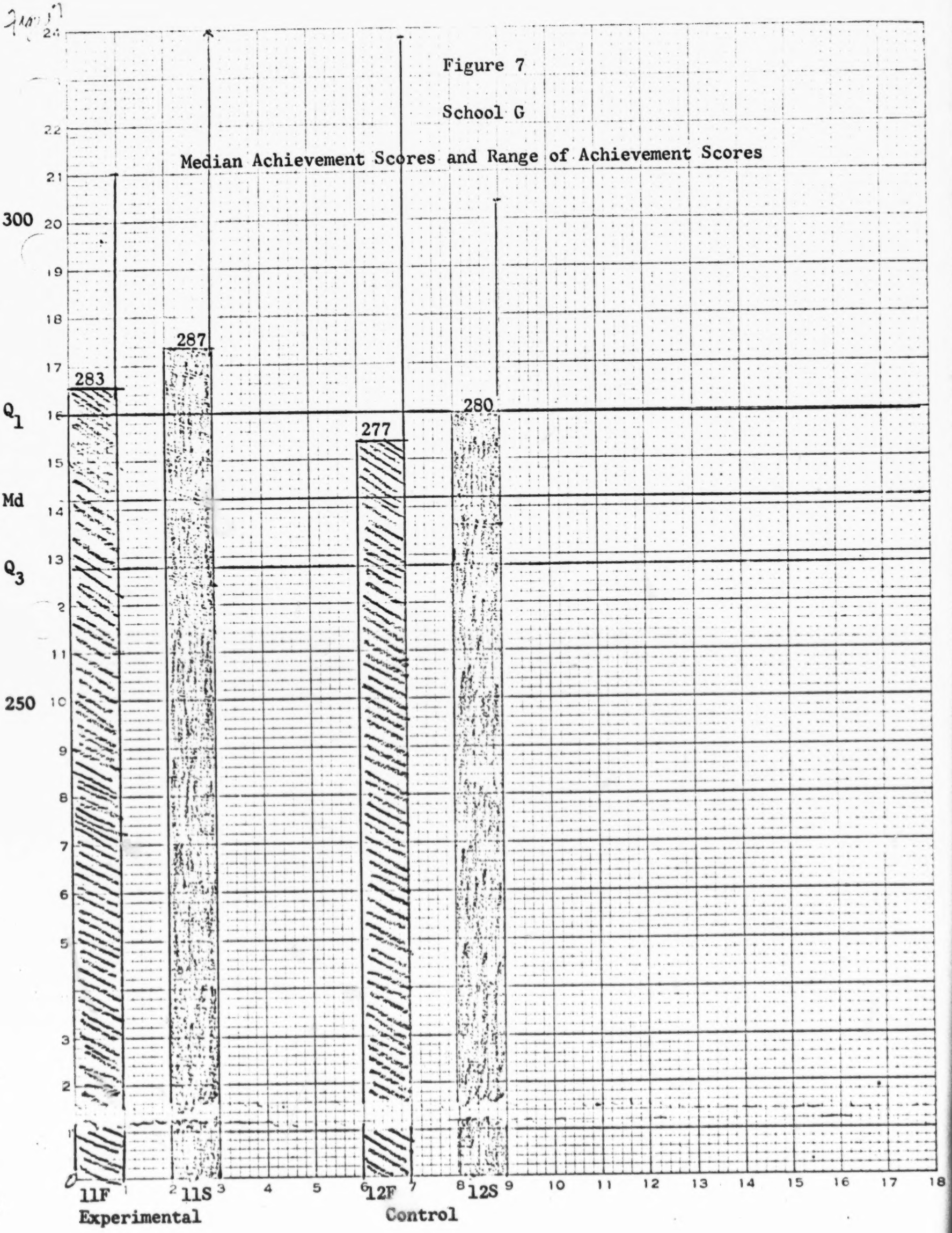


Figure 7

School G

Median Achievement Scores and Range of Achievement Scores



The teacher of division "a" had four classes. Three were experimental and one was the control. The median test scores of these four classes were above the national median on the pre and post STEP tests. The three experimental classes were above the first quartile. The range of scores for the pre-test STEP of the experimentals and control was from below the first quartile to above the third quartile. One experimental group range of scores was from above the national median score to above the third quartile in the spring post testing. The other three classes' ranges were from the first to third quartile. The gain in median scores of the control class was 2 points. The gains in median scores for the three experimental classes were 4, 10, and 19 points. This information is reflected in Figure 8.

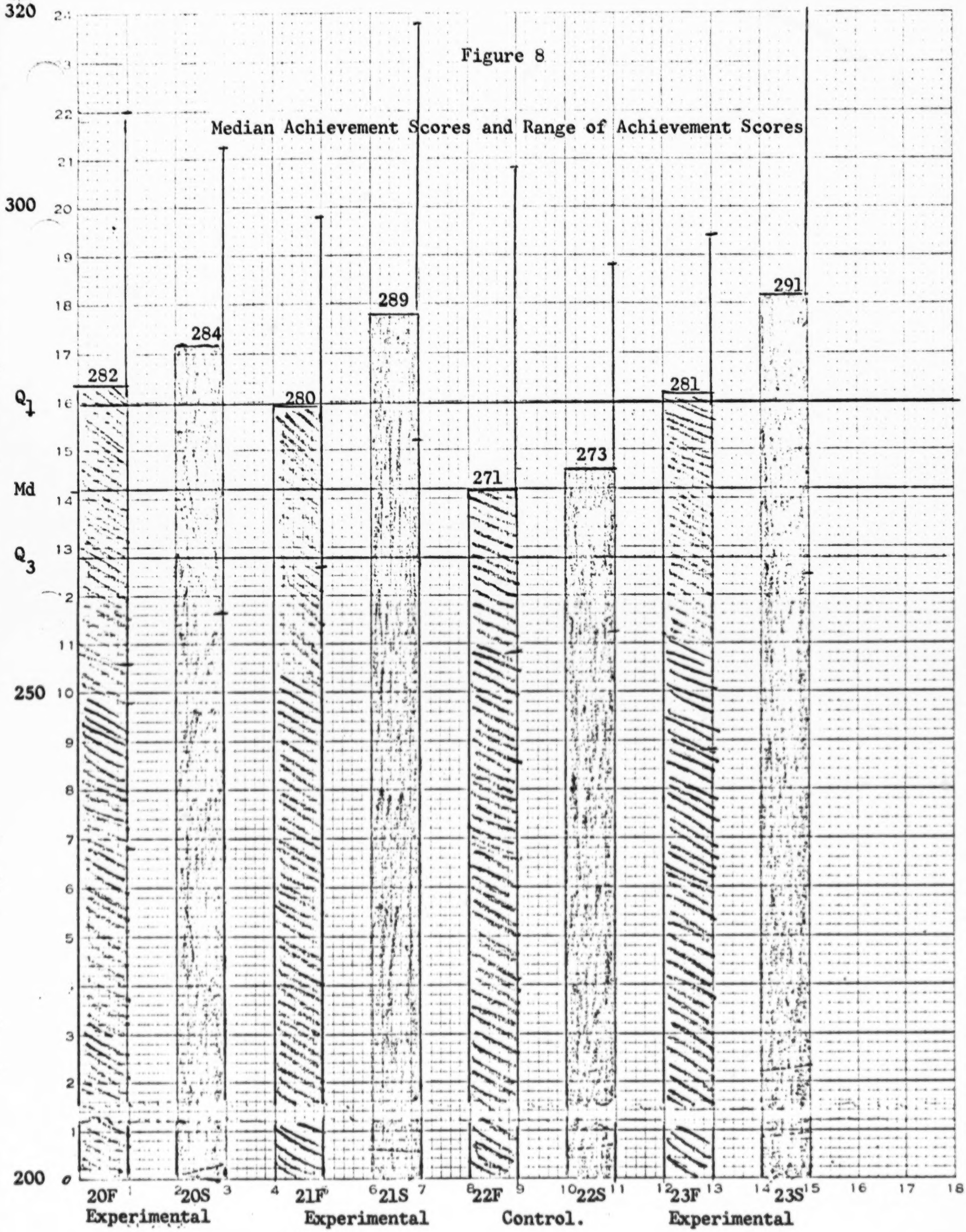
Statistical analysis indicated there were significant differences between the experimental and control classes at the .05 confidence level for the 110-119 I.Q. score classification level. There was also a probability between .05 and.10 for the 90-109 I.Q. level.

Division "b" consisted of five classes taught by another teacher. Three classes were the experimental groups and two were the controls. All five of these classes median scores were above the national median in the pre test and the post test. The three experimental classes median scores were above the third quartile in the pre and post tests.

The range of the experimental classes on the STEP test extended above the third quartile. The lowest STEP scores of two classes of the experimental group were above the national median in the spring testing. One experimental class did have scores in the first quartile. In the post test one experimental class scores were all above the third quartile.

Figure 8

Median Achievement Scores and Range of Achievement Scores

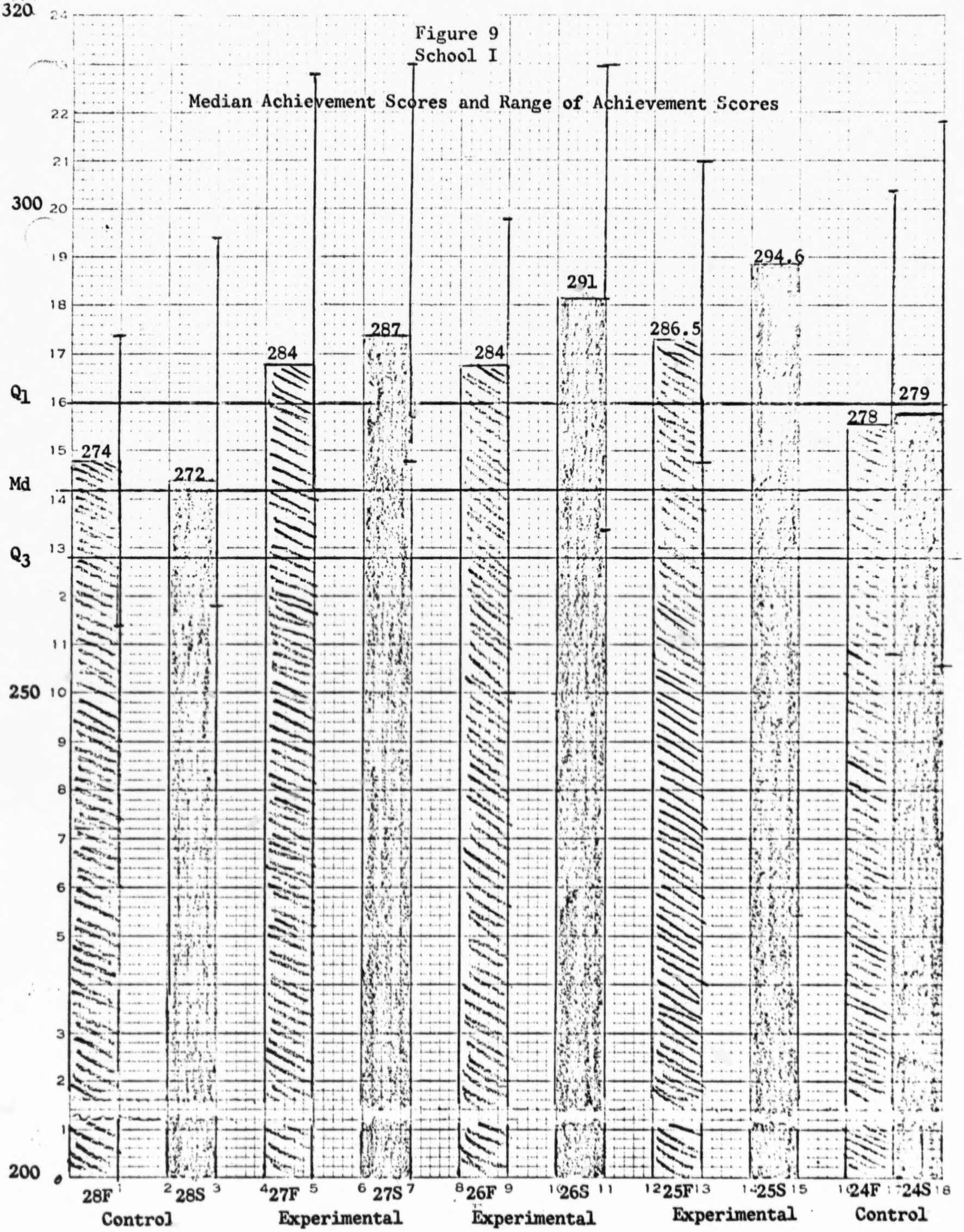


The control classes' range of scores was from the first quartile to the third quartile. These findings are shown in Figure 9.

As shown on table VI, statistical analysis showed that there were significant differences between the experimental and control group at the .01 and .05 confidence level for the 90-109 I.Q. classification level.

Figure 9
School I

Median Achievement Scores and Range of Achievement Scores



SUMMARY

1. Only classes in school I made any significant gains in achievement. Division "a" had significant gains in 110-119 I.Q. level at .05 confidence level. Division "b" had significant gains in 90-109 I.Q. at .01 confidence level.
2. Eleven out of the thirteen experimental classes had median scores above the national median in the STEP pre test. The number decreased to ten in the post testing.
3. The number of control classes with median scores above the national median score increased from six in the pre testing to seven in the post testing.
4. Seven classes of the control group had increases in median STEP scores. One class had a decrease in median score.
5. In the experimental group twelve classes had increases in median scores. One class had a decrease in the median score.
6. The range of scores did not change from the pre test to the post test for six classes of the control group. The range size decreased for six classes. Seven control classes had an increase in lowest and highest scores from fall testing to spring testing.
7. The range size from pre to post testing remained the same for eight classes and decreased for four in the experimental group. There was an increase in the lowest and highest scores for eight experimental classes.
8. In two control classes top score decreased by the lowest score increased in the spring testing.

9. In two experimental classes the bottom score decreased but top score increased from pre to post testing. In one experimental class the bottom score increased but the top score decreased from pre to post testing.

CHAPTER VI

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

SUMMARY

The study revealed the following:

1. The study group consisted of 647 students from seven schools, representing seven school units.
2. The types of schools represented were union schools, junior high schools, and senior high schools.
3. The types of communities represented were rural, semi-rural, and urban.
4. Seven of the fourteen teachers in the study attended the Atlanta Briefing Session.
5. The average number of undergraduate courses in chemistry and physics previously taken by the fourteen teachers in the study group was 2.7 and 1.4, respectively. Only four teachers had enrolled in graduate chemistry and physics courses.
6. The median I.Q. for the study group was 103.90.
7. There were twice as many students above the normal range as there were students below the normal intelligence range.
8. Only classes in school I made any significant gains in achievement. Division "a" had significant gains at the 110-119 I.Q. level at .05 confidence level. Division "b" had significant gains at the 90-109 I.Q. level at .01 confidence level.
9. Eleven of the thirteen experimental classes had median scores above the national median in the STEP pre test. The number decreased to ten in the post testing.
10. The number of control classes with median scores above the national median score increased from six in the pre testing to seven in the post testing.
11. Seven classes of the control group had increases in median STEP scores. One class had a decrease in median score.
12. In the experimental group twelve classes had increases in median scores. One class had a decrease in the median score.

13. The range of scores did not change from the pre test to the post test for six classes of the control group. The range decreased for six classes.
14. The range in pre and post test scores remained the same for eight classes and decreased for four in the experimental group. There was an increase in the lowest and highest scores for eight experimental classes.
15. In two control classes the top score decreased, but the lowest score increased in the spring testing.
16. In two experimental classes the bottom score decreased, but the top score increased in the spring testing. For one experimental class, the change in extreme scores was just the reverse.
17. Seven of the experimental classes had median scores above the national norm on the pre test. No control classes had median scores equalto or above the national norm in the fall testing.
18. The "total" post test results disclosed ten classes above the national norm. One of these was a control class.
19. Statistical significant differences in the understanding of science were found in four of the seven schools that participated.
20. For only one teacher at School I was there a statistical difference between control and experimental classes. This was at the 90-109 I.Q. level.
21. School G was the only school that had significant differences in understanding about the scientific enterprise. The significant difference was found at the 90-109 I.Q. level.
22. School E exhibited statistical difference at .05 confidence level for 110-119 I.Q. level.
23. In the area of understanding about the methods and aims of science School D had significant differences at .05 confidence level for the 110-119 I.Q. level. School E had statistical differences at .05 confidence level for the 120-139 I.Q. classification level. Division "a" of School I had statistical differences at the .01 confidence level for the 110-119 I.Q. classification leve. Division "b" had significant differences at 90-109 I.Q. level at the .01 confidence level.

Conclusions

Based on the above summary, the following conclusions regarding this study have been drawn:

(1) Pupils enrolled in the IME Program do score significantly higher in general science achievement than pupils taught by the conventional method under the following conditions:

a. The pupil has normal or above normal mental ability.
b. The pupil's previous general science achievement background is above average (national).
c. The teacher's physical science training is very strong.

(2) Pupils enrolled in the IME Program do score significantly higher in the area of understanding about the methods and aims of science under the following conditions:

a. When the pupil has normal or above normal mental ability.
b. When teacher's physical science background is above average.

(3) Pupils with slightly less than national average background in "total" understanding about science, enrolled in the IME Program, will score significantly higher in the area of the understandings about the scientific enterprise than similar pupils in the conventional program provided:

a. The pupil has normal or above normal intelligence.
b. Teacher has an adequate background in physical science training.

(4) Pupils with slightly less than average (national) background in "total" understanding in science do score significantly higher in the area of understandings about scientists than similar pupils in the conventional physical science program. However, the significant difference appears to be contingent upon the following:

a. Above normal mental ability.
b. Adequate physical science preparation of the teacher.

(5) Teacher attendance at the Atlanta Briefing Session had little or no effect in a significant gain of scores between pupils involved in the IME Program and the conventional physical science program.

Recommendations

A. To insure the success of a program such as the IME program the following criteria should be met.

(1) Pupils should be of normal or above normal mental ability.

(2) Teachers should be adequately trained in the physical sciences.

(3) Schools should be provided with basic science equipment and facilities. Although an inventory was not taken of the basic science equipment and materials of these schools, general observation indicated that the pupils enrolled in schools without the basic science equipment and materials did not score as high. The IME projects make the suggestion that very ordinary materials could be brought by the students or teacher and that some equipment and materials could be constructed by the students and the teacher. Nevertheless, the amount of time involved and the ingenuity of pupils and teachers can become crucial factors in obtaining the necessary materials and equipment.

(4) Pupils' previous experience and achievement in science should be at least average; if not, efforts should be made to upgrade the pupil's background and should be incorporated into the program.

B. It would be of interest to make a correlation study of the scores from standardized tests of general science achievement and science understanding and the scores of achievement tests given by curriculum developers of programs such as the Rand McNally Science Curriculum Project. Perhaps an experiment to reveal any significant difference in students' critical thinking ability should be designed to evaluate more of the new science programs' effectiveness.

C. Similar investigations should be made of the new science curriculum projects in the intact classroom setting.

CHAPTER V

THE TOUS TEST RESULTS

The TOUS test results are in four parts — the total, areas I — understanding about the scientific enterprise. Area II — understanding about scientists and Area III — understanding about the methods and aims of science.

The total pre test results revealed seven classes above the national norm. (Tenth grade norms were used because it was more representative. Ninth grade norm was taken from a small select sample).[8] All seven classes were in the experimental group.

The total post test results disclosed ten classes above the national norm. Nine of these classes were experimental ones.

The TOUS test had norms only for the total score. Therefore, test results for the three areas could not be compared to a national norm.

Appendix D contains national norms for the TOUS test.

Mann Whitney U test and Kruskel-Wallis One-Way Analysis of variance were the instruments used to determine statistical differences.

School A: Experimental and control classes were below the national norm score of 28.58 for the pre test and post test.

The median score of one control class was below the 8th percentile on the pre test and post test. The other control class median score was 21.2 on the pre test and 25.6 on the post test. This represented a gain of five points. The experimental class gained almost two points from the fall testing to spring testing. Nevertheless, the experimental class median pre test score and post test score were below the 25th percentile.

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[8] Manual for Administering, Scoring and Interpreting Scores TOUS (Test on Understanding Science) Form W. (1961) Educational Testing Service, Princeton, New Jersey.

The score range of experimental and control classes extended above the national norm. Figure 10 discloses this information.

There were no significant differences between the experimental and control classes of School A in any of the three areas of the TOUS or in the total scores. Tables VIII, IX, X and XI show this data.

School B: The median pre test and post test scores were below the national norm and below the 5th percentile rank. No class had scores on the pre or post test that ranged to the national norm. As indicated in Figure 11, however, the post test of the control class scores did range to the 46 percentile rank.

As shown in Tables VIII, IX, X, XI, statistical analysis of the classes at School B revealed no significant differences.

School C: School C had a wide variation of scores between the two experimental classes and the three control classes. Nevertheless, as shown in Figure 12, none of these classes had median scores above the national norm on their pre tests or their post tests. The median pretest score of the two experimental classes were above the 19th percentile rank. All pre test median scores of the control classes were below the 8th percentile rank.

All classes showed an increase in their post test scoring. The greatest increase was found in the experimental groups. The range of scores was the greatest in the experimental groups in the pre and post tests. The experimental classes" range extended above the 98th percentile on the post test. The pre test range of one class extended to the 72nd percentile rank. For the other classes it did not extend beyond the 52nd percentile rank on either the pre test or post test.

Table IX

Tous Statistical Results (Area I)

	A	B	D	E	G	C	Ia	Ib
IQ	1 2 3	5 6	7 8	9 10	11 12	15 16 17 18 19	20 21 22 23	24 25 26 27 28
120 - 139	-	-	NS	NS	NS	-	-	-
110 - 119	-	-	NS	NS	NS	-	NS	NS
90 - 109	NS	-	NS	NS	Significant .05	NS	NS	NS
80 - 89	NS	NS	-	-	-	-	-	-
70 - 79	-	NS	-	-	-	-	-	-
60 - 69	-	-	-	-	-	-	-	-

Table X

Tous Statistical Results (Area II)

	A	B	D	E	G	C	Ia	Ib
IQ	1 2 3	5 6	7 8	9 10	11 12	15 16 17 18 19	20 21 22 23	24 25 26 27 28
120 - 139	-	-	NS	NS	NS	-	-	-
110 - 119	-	-	NS	Significant .05	NS	-	NS	NS
90 - 109	NS	-	NS	NS	NS	NS	NS	NS
80 - 89	NS	NS	-	-	-	-	-	-
70 - 79	-	NS	-	-	-	-	-	-
60 - 69	-	-	-	-	-	-	-	-

Table XI

Tous Statistical Results (Area III)

	A	B	D	E	G	C	Ia	Ib
IQ	1 2 3	5 6	7 8	9 10	11 12	15 16 17 18 19	20 21 22 23	24 25 26 27 28
120 - 139	-	-	NS	Significant .05	NS	-	-	-
110 - 119	-	-	Significant .05	NS	NS	-	Significant .05 & .01	NS
90 - 109	NS	-	NS	NS	NS	NS	NS	Significant .05 & .01
80 - 89	NS	NS	-	-	-	-	-	-
70 - 79	-	NS	-	-		-	-	-
60 - 69	-	-	-	-	-	-	-	-

2

Table VIII

Tous Statistical Results (Total)

	A			B		D		E		G		C					Ia				Ib				
IQ	1	2	3	5	6	7	8	9	10	11	12	15	16	17	18	19	20	21	22	23	24	25	26	27	28
120 - 139		-			-		NS		NS		NS			-					-				-		
110 - 119		-			-		NS		NS		NS			-					NS				NS		
90 - 109	NS			-		NS		NS		NS		NS					Significant				NS				
80 - 89	NS			NS		-		-		-		-					-				-				
70 - 79	-			NS		-		-		-		-					-				-				
60 - 69	-			-		-		-		-		-					-				-				

Fig

Figure 10

The Range and Median of the Total Scores of Understandings about Science - School A

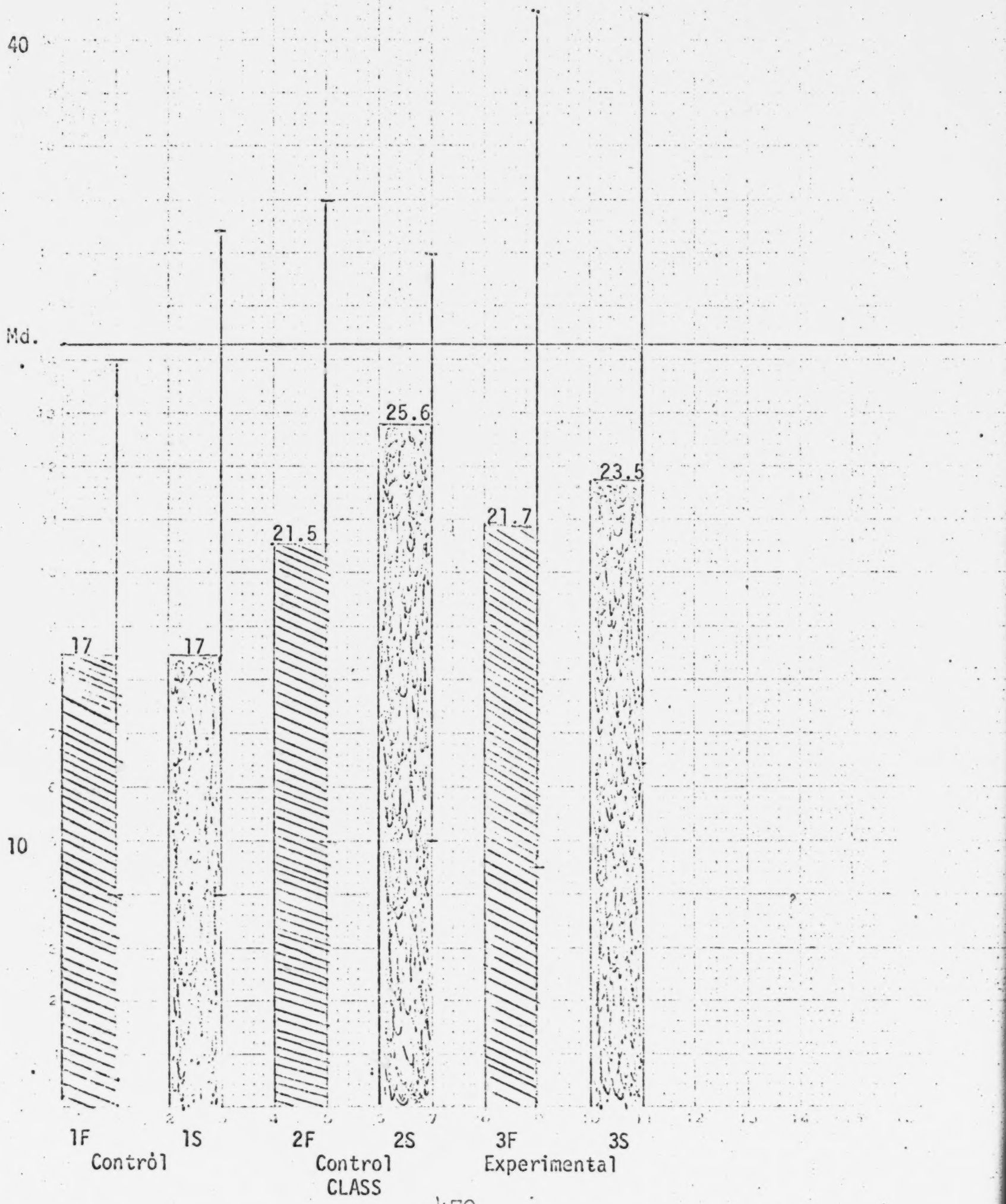


Fig 11

Figure 11

The Range and Median of the Total Scores of Understandings about Science - School B

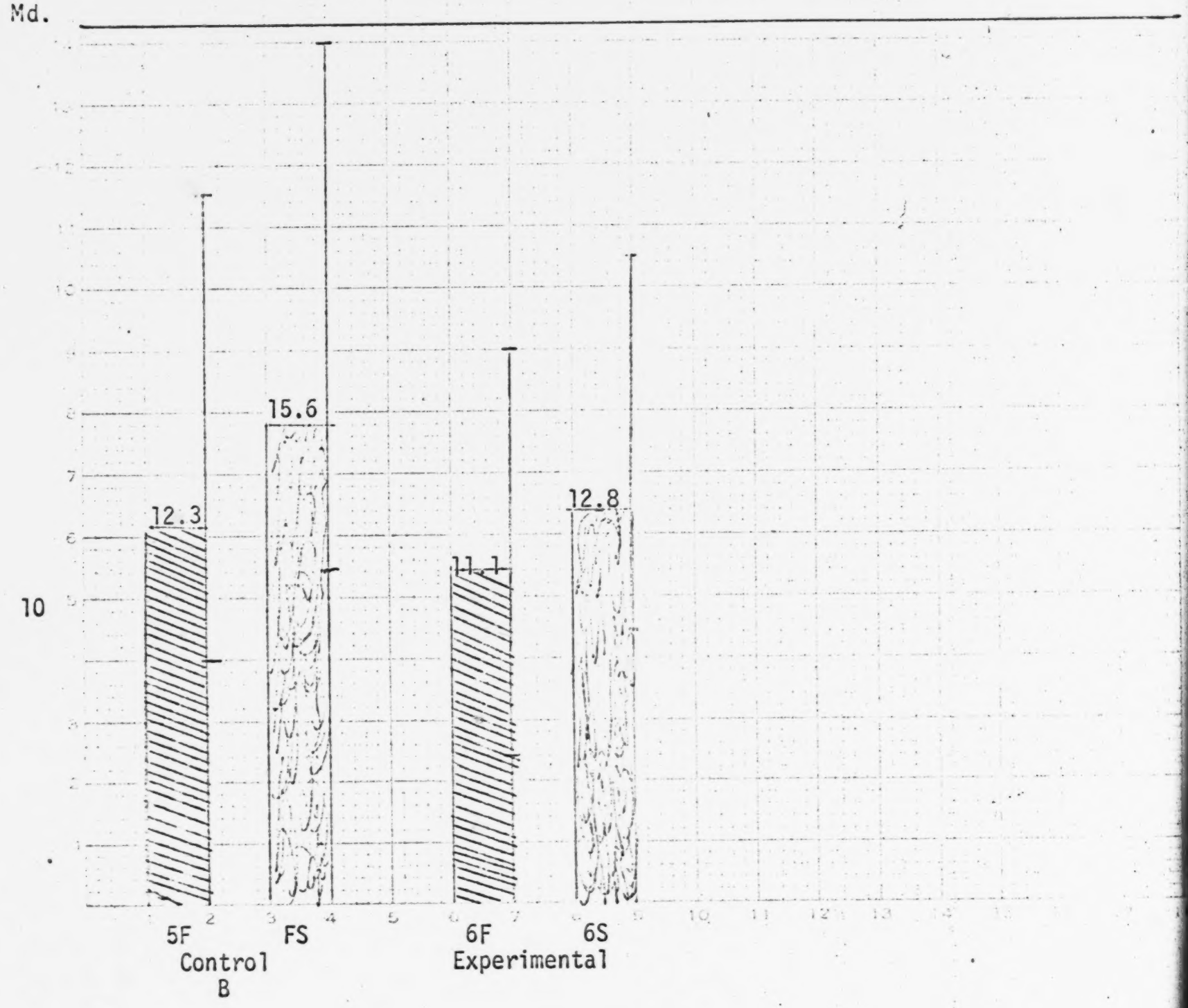
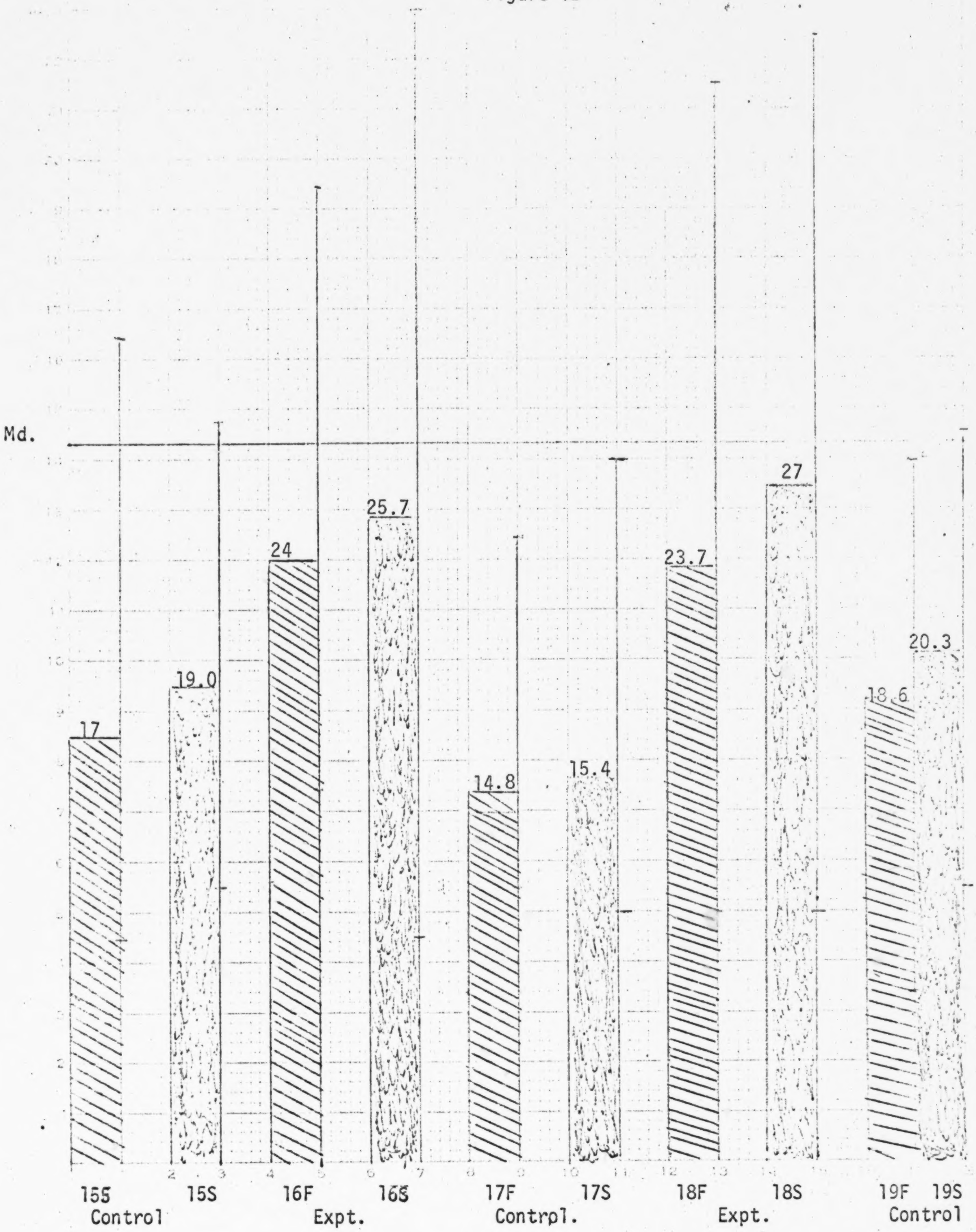


Fig 12. The Range and Median of the Total Scores of Understandings about Science School C

Figure 12



C

There were no significant gains among the experimental or control classes.

School D: As figure 13 reveals, the median scores for the experimental and control classes were below the national norm on the pre test.. The median score for the experimental class pre test had a percentile rank of 46. The control class pre test had a percentile rank above 40. The range of percentiles for the experimental and control classes was from below the 2nd to the 86th. The median score of the experimental class increased to 30.8 on the post test from 28 on the pre test. The median score of the experimental group was above the national norm. The control median scores decreased from 26.9 on the pre test to 26.2 on the post test. Both scores were below the national norm. There was no substantial change in the control class for any I.Q. level. Tables VIII, IX, X and XI reflect these findings.

School E: The median pre test scores of both the control and experimental classes were less than one point below the national norm. As shown in Figure 14, the median score of the post test of the control class was 33. This score had a percentile rank of 72. However, the average score or arithmetic mean score was more than one point below the national norm.

The pre test and post test median scores of the experimental class were above the national norm. The median percentile rank on the post test was 81. The percentiles of the post test ranged from 8 to 99. The post test of the control class had a percentile range from 2 to 98.

The statistical results from comparisons of the control and experimental classes indicated no significant differences. Tables VIII, IX, X, XI indicate these findings.

Fig 13

Figure 13

The Range and Median of the Total Scores of Understandings about Science - School D

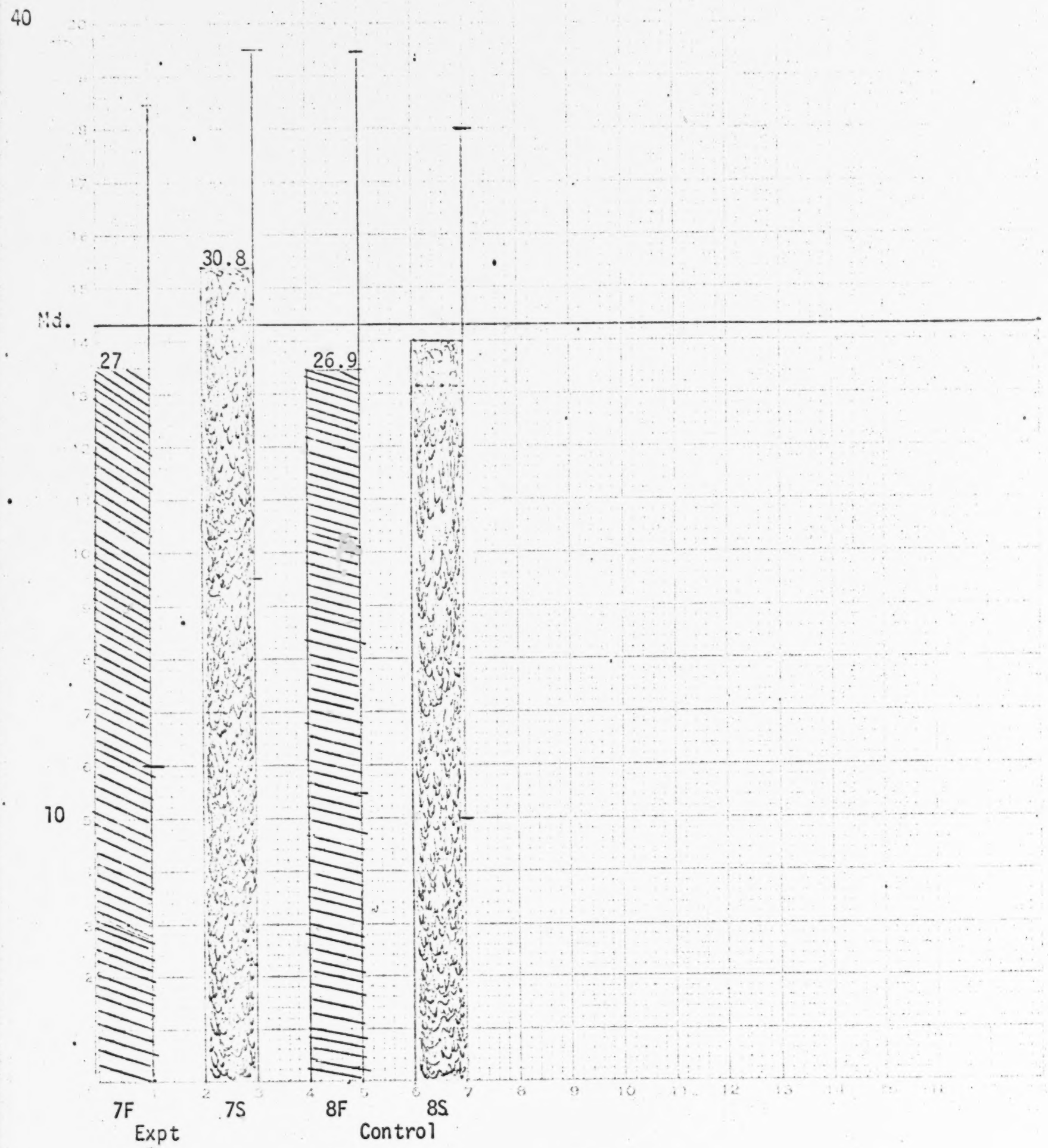
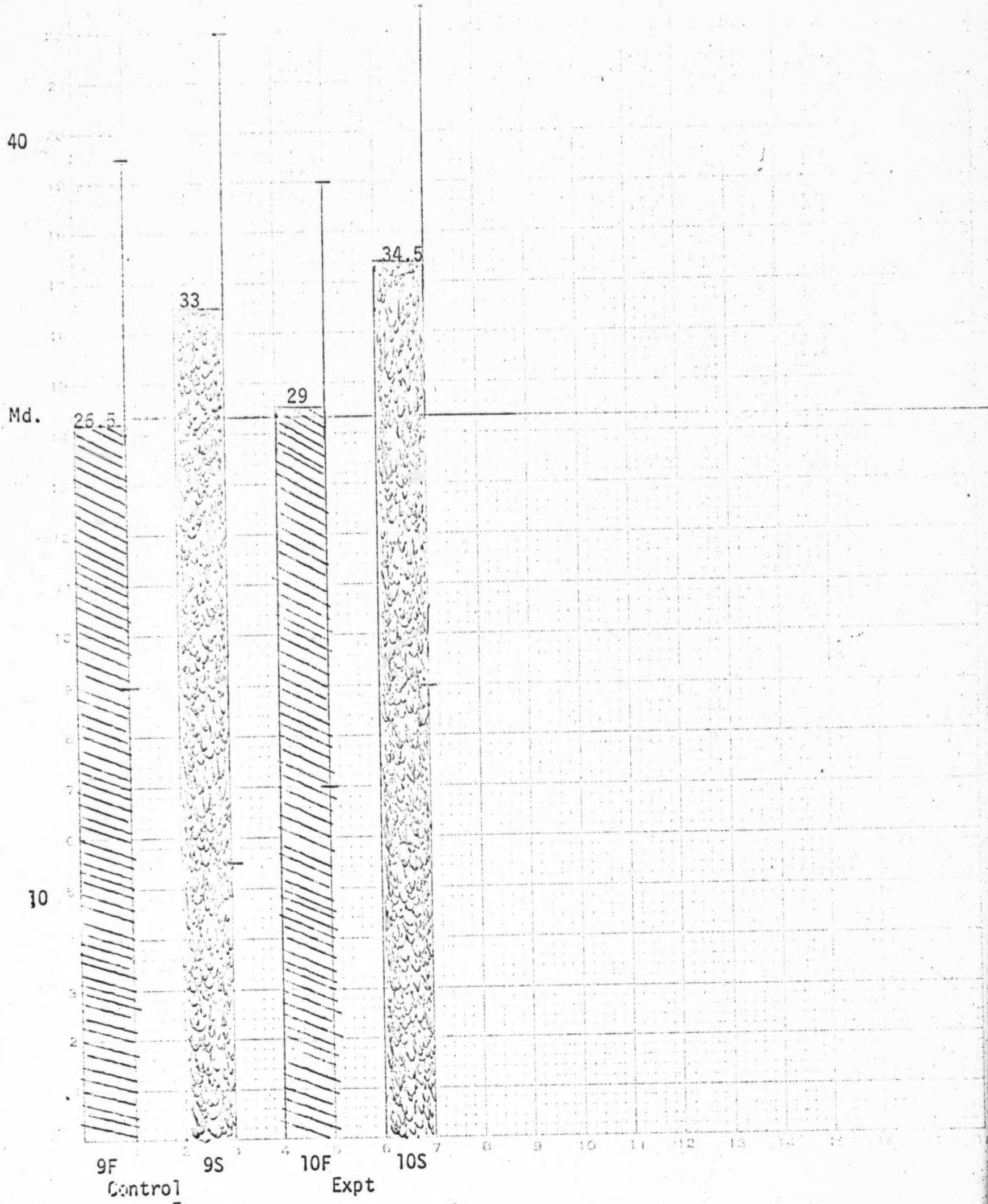


Fig 14

Figure 14

The Range and Median of the Total Scores of Understandings about Science - School E



School G: Experimental and control classes had approximately the same range of scores on their pre test. This is shown in Figure 15. The median scores of the experimental class were above those of the control classes on the pre-test and post test. However, the range of the post test scores of the experimental class was much narrower than that of the post test scores of the control class. The range of percentiles on the post test of the experimental classes was from 28 to 48 compared to 19-94 for the control class.

There were no significant differences found between the control class and experimental class of School G.

School I: Division "a" was the only group that showed any significant gain among the control and experimental classes. This was found at the 90-109 I.Q. classification level. As shown in Figure 16, the median scores of the experimental classes, pre test and post test, were above the national norm. The experimental classes' gain in scores varied 2 to 3 points. The lowest percentile rank of the experimental class was below 12 and the highest above 99.

In spite of the small overall gain of the experimental classes over the control classes there was a significant difference in gain scores between the experimental classes and the control at the .05 confidence level.

Division "b" had a similar distribution of median scores for the experimental classes and the control classes. Figure 17 reveals these findings. The control classes' median scores were below the national norm on the pre-test and post test. These median scores varied from the 19th to 28th percentiles. There was a decrease of one point for one control class and an increase of less than a point for the other class from pre test to post test median scores. The lowest experimental class pre test

Fig 15 The Range and Median of the Total Scores of Understandings about Science - School G

Figure 15

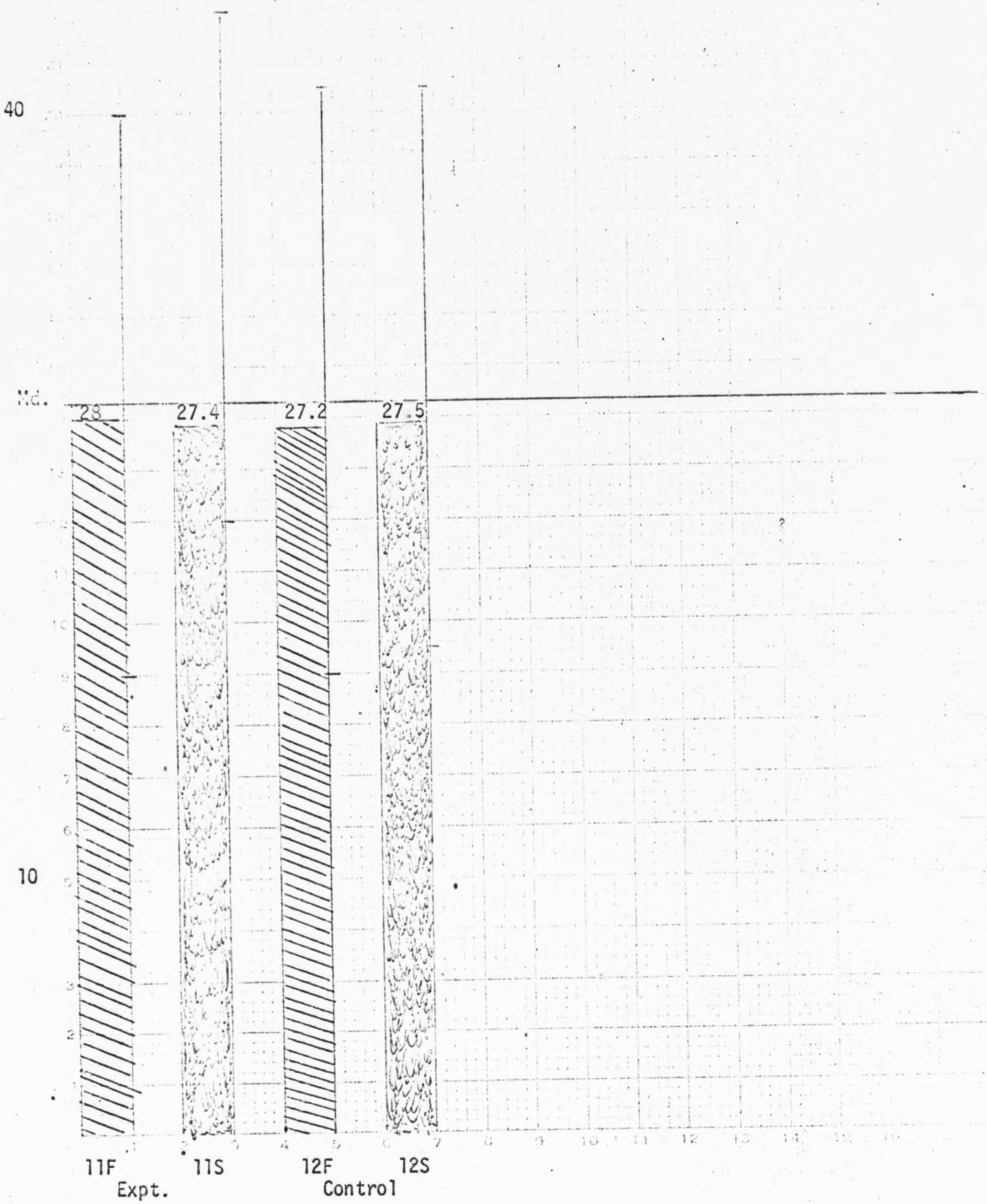
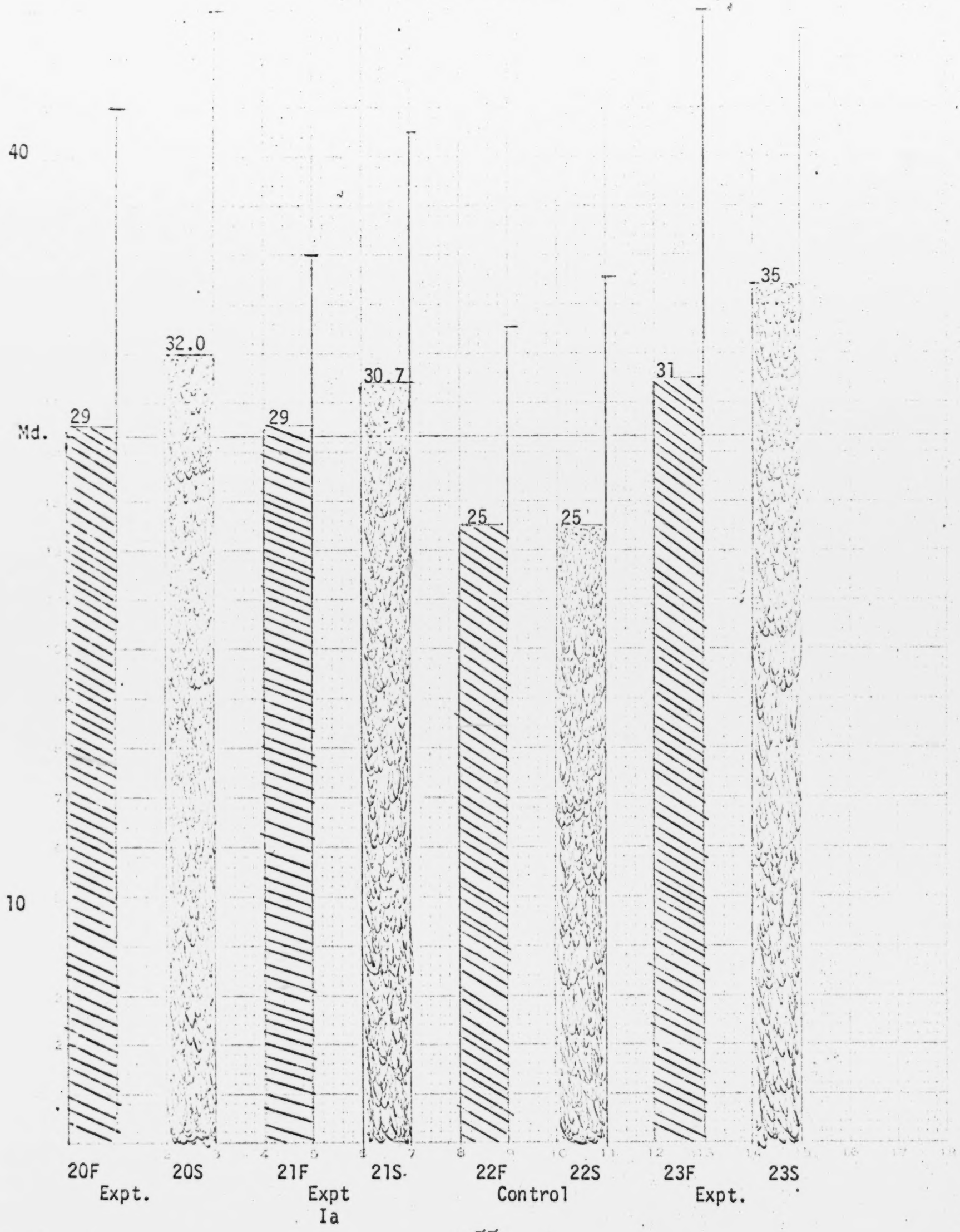


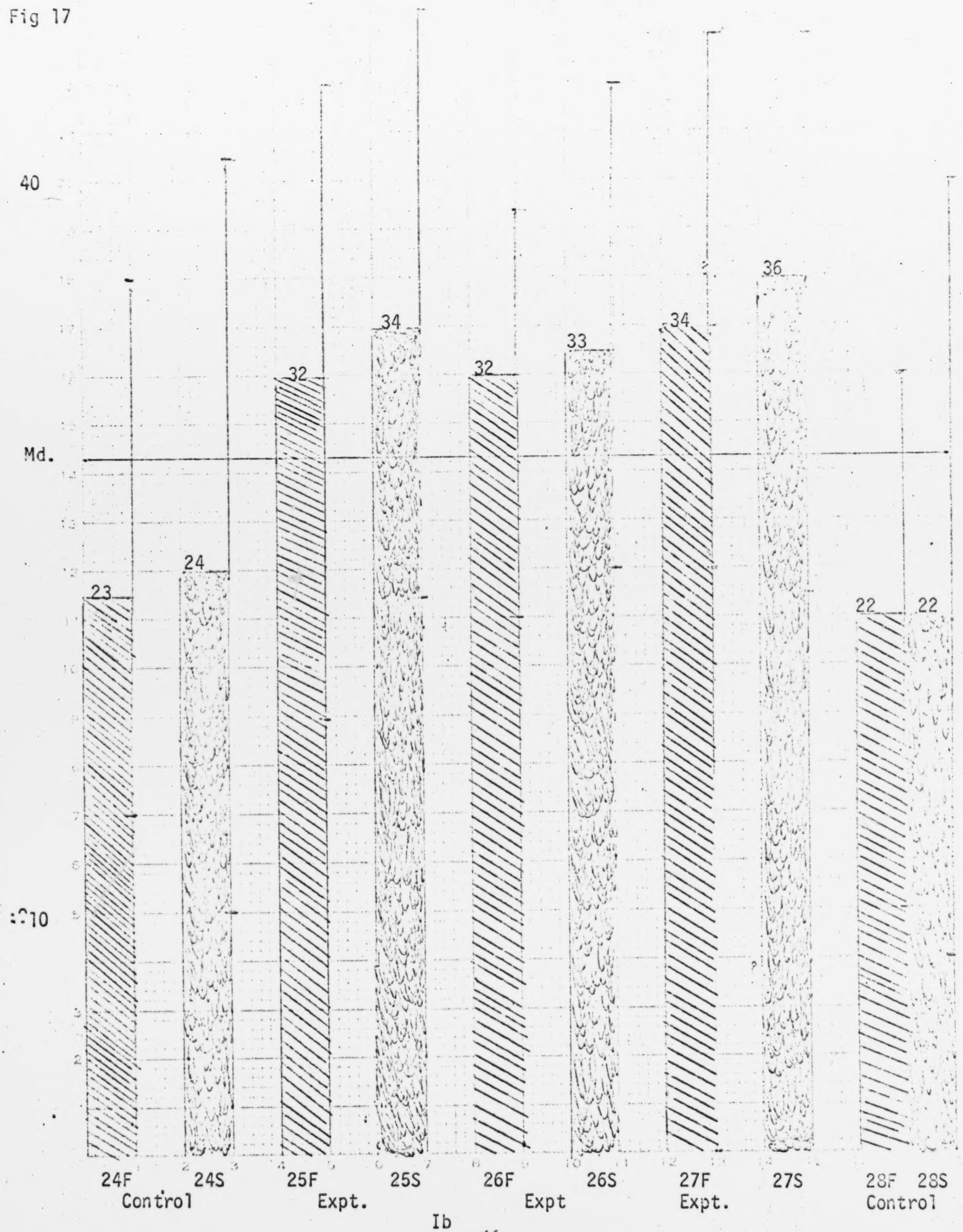
Fig 16 The Range and Median of the Total Scores of Understandings about Science - School I/

Figure 16



The Range and Median of the Total Scores of Understandings about Science - School IB

Fig 17



Ib

median score was the 67th percentile. The lowest for the post test was the 72nd percentile. The gain for two of the experimental classes was between 2 and 3 points. One class lost one and one-half points from the pre test to the post test. The highest percentile rank of the experimental class was over 81. The range of pre test scores of the control classes varied from the 3rd percentile to the 84th percentile. The post test of the control varied from the 3rd percentile to above the 92nd percentile.

As indicated in Tables VIII, IX, X and XI, statistical comparison by I.Q. classification levels revealed there was no significant difference between gain of scores between the experimental and control groups.

The Area of Understanding: In Area I, understanding about the scientific enterprise, School G was the only school that had a significant difference between control and experimental classes. Table IX shows that the significant difference was at the 90-109 I.Q. classification level.

In Area II, understanding about scientists, School E showed a significant difference at the .05 confidence level at the 110-119 I.Q. level. As shown in Table X other schools did not exhibit any significant differences.

The experimental and control groups at three schools showed significant differences in the understanding about the methods and aims of science. Area III: Division "a" of School I showed significant difference at the .05 confidence level for 110-119 I.Q. level. Division "b" of School I had significant differences at the .05 and .01 confidence levels for 90-109 I.Q. levels. School D exhibited significant difference for 110-119 I.Q. level at the .05 confidence level. School E exhibited significant difference at .05 confidence level for the 120-139 I.Q. level.

SUMMARY

1. Seven of the experimental classes had median scores above the national norm on the pre test. No control classes had median scores equal to or aboe the national norm in the pre testing.

2. The "total" post test results disclosed ten classes above the national norm. One of these was a control class.

3. Significant differences in gains in the understanding of science were found in four of the seven schools that participated.

4. Division "a" of School I was the only study that showed significant differences among the experimental and control classes in the total TOUS. The differences were at 90-109 I.Q. level.

5. School G was the only school that had significant difference in gain in understanding about the scientific enterprise. The significant difference was found at the 90-109 I.Q. level.

6. School E exhibited significant difference at .05 confidence level for 110-119 I.Q. level in gain in the understanding about scientists.

7. In gain in understanding about the methods and aims of science, School D had significant difference at .05 confidence level for the 110-119 I.Q. level. School E had significant difference at .05 confidence level for the 120-139 I.Q. level. Division "a" of School I had significant difference at the .01 and .05 confidence level for the 110-119 I.Q. classification level. Division "b" had significant difference at 90-109 I.Q. level at the .01 and .05 confidence level.

APPENDICES

APPENDICES

A - Number and Per Cent of Students Enrolled in Physical Science and Participating in the Study

B - Interquartile Norm Ranges

C - Interquartile I. Q. Ranges

D - Tentative Norms - Test on Understanding Science (TOUS) Percentile Ranks for High School Students

APPENDIX A

Number and Per Cent of Students Enrolled
in Physical Science and Participating in the Study

School	Physical Science Sections		Physical Science Membership	Students in Study	
	Total	Participants		Number	Percentage
A	3	3	106	106	100
B	3	2	87	46	52.9
C	5	5	160	160	100
D	12	2	377	67	17.8
E	12	2	411	56	13.6
F	2	2	57	57	100
G	8	2	186	54	29.0
H	3	2	87	56	64.4
I	11	9	323	280	86.7
Total	59	29	1,794	882	49.2

APPENDIX B

Interquartile Norm Ranges

	I.Q.[1]	STEP[2]	TOUS[2,3]
Q_3	118	280	33.60
Median	103.9	271	28.60
Q_1	89.64	263	23.40

1. Study group norm
2. National Norm
3. Obtained from the percentile rank of TOUS's tentative norm

APPENDIX C

Interquartile I.Q. Ranges

School	A			B		D		E		C					G		I"a"				I"b"				
Class	1C	2C	3E	5C	6E	7C	8E	9C	10E	15C	16E	17C	18E	19C	11E	12C	20E	21E	22C	23E	24C	25E	26E	27E	28C
Q_3	96	104	104	85	81	112	112	118	120	97	115	85	110	95	120	120	116	120	107	120	115	128	124	122	105
M	91	95	96	83	78	105	108	109.5	111	895	105	77	99	89	110	114	112	113.5	102	115	107	118	115	118	101.5
Q_1	83	90	86	78	75	97	105	104	105	83	95	73	96	85	103	108	109	110	95	108	102	114	108	112	96
Q	6.5	7	9	3.5	3.0	7.5	3.5	7.0	7	7	10	6	7	5	8.5	6.0	3.5	5	6	6	6.5	2	8	5	4.5

APPENDIX D

TENTATIVE NORMS -- Test On Understanding Science (TOUS)

Percentile Ranks for High School Students*

TOUS Total Score	Grade 9#	Grade 10	Grade 11	Grade 12
48				99
47			99	
46		99	98	98
45			97	96
44		98	96	95
43		97	94	93
42		96	92	90
41	99	94	90	88
40	98	92	87	85
39	97	91	84	82
38	94	89	81	78
37	90	86	78	74
36	85	84	74	69
35	81	81	69	63
34	75	77	64	59
33	69	72	58	54
32	64	67	52	47
31	58	63	46	41
30	52	58	41	36
29	45	52	36	32
28	38	46	31	28
27	32	40	28	24
26	27	36	22	20
25	22	32	18	16
24	17	28	15	14
23	12	23	12	12
22	10	19	9	9
21	9	16	7	7
20	7	14	5	5
19	6	11	4	4
18	4	8	2	3
17		7		2
16	2	5	1	
15		4		1
14		3		
13		2		
Mean Score	29.47	28.58	31.57	32.25
Standard Deviation	6.03	7.66	7.02	7.38
Number of Students	198	1064	994	753

* Based on a nationwide sample of 3009 public and private school students tested in October 1960. (The means and standard deviations are based on 2980 of the 3009 students: 9th Grade, 198 students; 10th Grade, 1055; 11th Grade, 985; 12th Grade, 742.)

Figures for Grade 9 should be used with caution, since they are based on a relatively small sample group.

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